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for November, 1937

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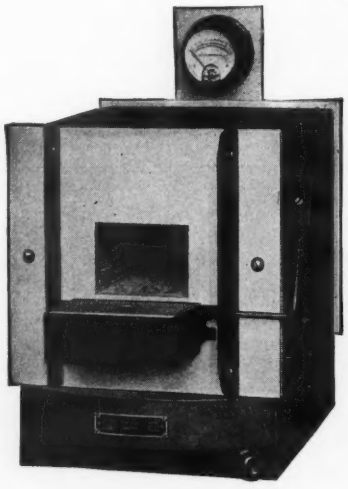

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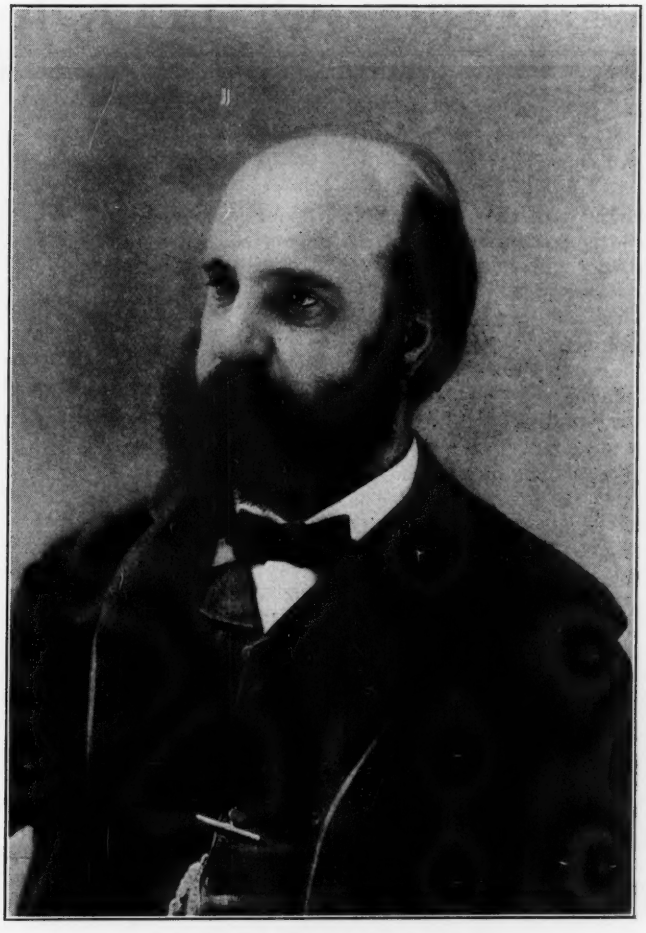

HENRY C. BOLTON

(See "The Past and Future of the History of Chemistry Division," pp. 503–16)

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EDITOR'S OUTLOOK

"WHY CHEMISTS GET FIRED." We had meant to hold off until the symposium on this subject projected for the September, October, and November numbers of *Chemical Industries* had been completed, but curiosity and an approaching editorial deadline have broken down our resistance. It is not, of course, our intention to report the symposium in such detail that our readers will feel it unnecessary to consult the original—quite the contrary. Indeed we strongly recommend, not only that all educators of prospective industrial chemists refer to these brief discussions themselves, but that they make them required reading for their students. Not that students are advised to take all they find therein for gospel. Like all collections of opinions, they represent occasional mutual contradictions. The prospective chemist, however, should take at least as much pains to inform himself concerning prospective employers, their demands and their psychology, as employers take in investigating prospective employees. Moreover, he will find that many of the faults that industrialists impute to employees are either personal or attributable to defects in education for which the student is more responsible than his teachers.

For example, several employers say that many chemists who come to them have apparently memorized facts and principles without thoroughly understanding them and without acquiring any idea at all about how to make use of them. The good teacher does much to discourage that sort of thing, but he can't do the whole job without a little active coöperation on the part of the student. If, having memorized a fact, a student asks himself what it means, what it implies, and why he has learned it, and if it seems to him essentially meaningless, sterile of significant implication, and useful for examination purposes only, he had better either change schools or quit school altogether. Something is wrong, either with his teacher or with him.

About one-third of the contributors agree that the average applicant for a chemical position can neither speak nor write English. One cites such horrible examples that only an editor could take him altogether seriously. This is another defect that demands the student's personal attention. His chemistry instructors may heckle him during recitations, they may annotate his reports and quiz papers with caustic comments, but they can't help him much if he won't help himself. Furthermore—perhaps we shouldn't add this, but we hope that truth may prove a sufficient defense against the charge of libel—the odds are about eight to three that they themselves neither speak nor write English. The trouble, however, apparently lies deeper than ignorance of, or difficulty in employing, the mechanics of language. It begins when the student or the young employee lacks a clear-cut idea of what he has to say, and of how much of it his superior wants to know. Once this obstacle is overcome the average young chemist will find his greatest handicap the paucity of his vocabulary. He recognizes on the printed page, and pronounces when necessary, many words that convey only the foggiest of meanings to him. Since he doesn't really understand them they can form no part of his working vocabulary. The aid of a good dictionary in reading is the best remedy for this defect.

This, of course, is only a part of the story of the young chemist as his employer sees him. True to our pledge not to tell all, we repeat our advice that students consult the symposium itself, and urge them to be guided to more active participation in their own training.

The PAST *and* FUTURE *of the* HISTORY *of* CHEMISTRY DIVISION*

C. A. BROWNE

Bureau of Chemistry and Soils, Washington, D. C.

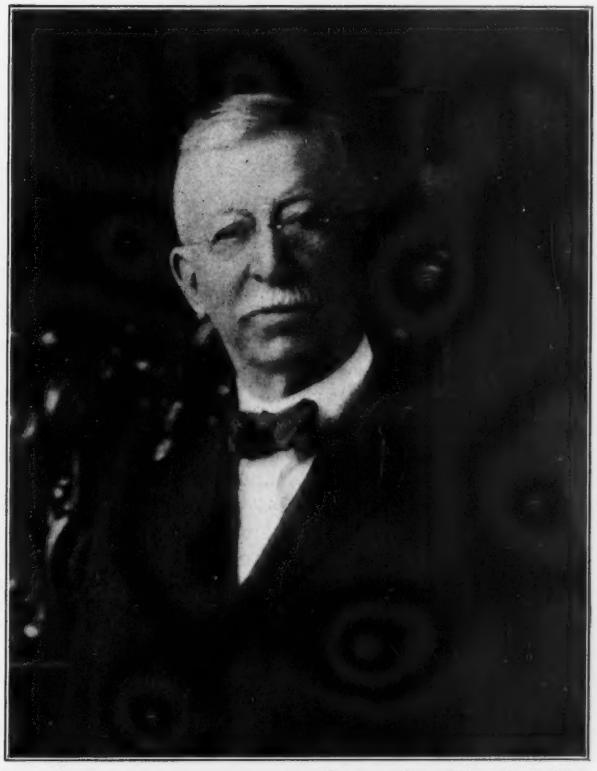
THE History of Chemistry movement in the United States dates back to the very commencement of chemical instruction in our colleges and universities. An inspection of the early courses in chemistry, as revealed by outlines of lectures and by student notebooks, shows that a certain amount of historical instruction was imparted in the classroom at an early date in addition to the usual information on the composition and properties of matter. The early chemical courses were in large part based upon the procedure followed in European textbooks and universities, in which historical references always played a more or less prominent part.

The references to historical matters in early American chemical instruction were confined, however, to European developments, and little was said or written about American contributions until after the Civil War. This statement does not apply, however, to chemical industry which was the earliest phase of American chemistry to attract attention. Tariff rulings and other legislation affecting the early industries of iron, sugar, distilling, leather, soap, naval stores, potash, salt, etc., both in colonial and post-revolutionary days resulted in the collection of important historical data that found its way into resolutions, appeals, reports, and other documents which, both published and unpublished, are still sources of valuable information to the historical student. Thus it happened that historians of American commerce and industry, such as Dr. J. Leander Bishop, author of the well-known "History of American Manufactures from 1608 to 1860," were the first historians of American chemistry.

AMERICAN HISTORIANS OF CHEMISTRY

The first professor of chemistry in an American university to undertake a serious, thorough study of the History of Chemistry in America was Professor Benjamin Silliman, Jr., of Yale, whose important series of articles entitled, "American Contributions to Chemistry" in Vol. V of the *American Chemist* for 1874, and afterward published in book form, have been a valuable source of information to subsequent writers, who, unfortunately, have not always given due credit to the author of their citations.

Contemporaneous with the younger Silliman in exploring the history of chemistry was Professor Henry C. Bolton whose scholarly contributions during the last three decades of the previous century have greatly enriched the literature of the subject. Bolton's compendious "Bibliography of Chemistry" in five volumes is one of the most helpful historical compilations ever published. It is indispensable to the historical student of chemistry, no matter in which special field of the science he may be interested. Dr. Bolton in his historical studies collected one of the largest private libraries of old chemical books ever assembled in the United



Courtesy Mrs. Edgar F. Smith

EDGAR F. SMITH

* Presented before the Division of History of Chemistry at the ninety-fourth meeting of the American Chemical Society, Rochester, N. Y., September 6, 1937.

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States. The flyleaves of these books are often annotated with Bolton's interesting notes in beautiful script regarding the author or edition or circumstances attending his acquisition of a particular work. Bolton's valuable collection of rare chemistry books was donated

BENJAMIN SILLIMAN, JR.

after his death by Mrs. Bolton to the Library of Congress. The most interesting and valuable of these works is Bolton's extra-illustrated set of Poggendorff's "Biographical Dictionary of Scientists"—the like of which probably cannot be found in any library of the world.

Bolton's interests in historical chemistry were confined largely to early European developments; further pursuit of the history of chemistry in America, after it was dropped by the younger Silliman, had to await the coming of Professor Edgar Fahs Smith. After twenty years of authorship of chemical textbooks and laboratory manuals Professor Smith, in the late nineties, began to turn his attention to the writing of short biographies of American chemists, in which special field of writing he became the outstanding authority. His first historical volume, "Chemistry in America," published in 1914, was the outcome of courses of lectures on the development of chemistry in the United States before graduate students of the University of Pennsylvania, of which he was later Provost. The book, as indicated by the subtitle, "Chapters from the History of the Science in the United States," was not intended to be a comprehensive work. More attention was given to chemical developments in Dr. Smith's native state, which was the special field of his historical investigations, than to the course of chemistry in other parts of the country. He fully realized this limitation and thought at one time of bringing out a new edition of his book with a better-balanced presentation of the work done in all parts of the country. He did not live, however, to realize the accomplishment of this plan. It was his hope that chemists in Boston, New York, Baltimore, Pittsburgh, New Orleans, Chicago, San Francisco, and other cities of the United States would investigate the origins of chemistry in their respective localities, as he had done in Philadelphia. The stimulation of such inquiries was, in fact, one of his main purposes in organizing a section upon the "History of Chemistry" as a part of the semiannual meetings of the American Chemical Society.

CONCEPTION OF THE HISTORY OF CHEMISTRY SECTION

The events which led to the establishment of a "History of Chemistry Section" at the Rochester meeting of the American Chemical Society in April, 1921, were as follows. Various historical items, which the writer had published in *Science*, the *Scientific Monthly*, and in *Industrial and Engineering Chemistry* had come to the attention of Dr. Smith, and so at the Chicago meeting of the Society in September, 1920, we had our first conference upon the subject. I quote from my journal.

September 7, 1920

MEETING OF THE AMERICAN CHEMICAL SOCIETY

AT EVANSTON, ILLINOIS

At Evanston we assembled at 3 P.M. in the Gymnasium of the Northwestern University. Drs. Parsons, Herty and many others, whom I chanced to meet, informed me that Professor E. F. Smith (Provost of the University of Pennsylvania) was anxious to see me, and I soon found him in the Gymnasium. He had heard of my collection of autograph letters, prints, etc., of famous chemists and desired to discuss things with me, as he was greatly interested in historical chemistry. We sat for a while in the Gymnasium listening to the speakers, but it was so warm, we finally went outside and taking a shady seat under the trees on the lake front, spent over an hour in pleasant conversation.

I gave Professor Smith some photos of Priestley's bookplate, which I had with me and which he was pleased to have. He said he had a book with a Priestley plate but it was only a name plate without any artistic illustration. I told him of the old book which I had that contained the plate and of my desire to consult the inventory, that was made of Priestley's library after the Birmingham riots, to see if this book was listed. I had been unable to trace the history of the book. I mentioned also a letter by Priestley, which I had, written from Reading to Mr. Vaughan in Philadelphia. Professor Smith told me about Vaughan and his relations with Priestley.

I told Professor Smith about visiting the old Priestley house in Northumberland, Pennsylvania, some time in 1897 or 1898, and of my desire to visit the place again before the building was taken down for shipment to State College. Professor Smith said it was not certain that the building would be moved as Professor Pond had not succeeded in raising the necessary funds for this before his death, and since his death the owners of the property had written him, asking that the American Chemical Society buy the property. Professor Smith said he believed that Professor Pond's travels about the country to raise funds to move the house were in a way the cause of his illness and death. He felt that it would be better, if possible, to preserve the home where it was and that the moving of the house from its old setting and associations would be a loss. I told Professor Smith that the chemistry alumni of Pennsylvania State seemed determined to carry out Professor Pond's original plans and to raise the funds necessary to move the house. I spoke of Priestley's old method of curing lumber in a fire-pit and expressed the opinion that if the

old house were taken apart, many of the original boards would be found with the smoke stains.

Professor Smith mentioned his having obtained the old balance of Priestley from his descendants in Northumberland and that he was uncertain what disposition to make of this. He felt in some ways that it should belong to the University of Pennsylvania and then again that it should belong to the National Museum in Washington.

Professor Smith asked if I thought there were enough members of the American Chemical Society interested in Historical Chemistry to establish a section. I told him I thought there were if they could ever be induced to come together and I named a number of members who were interested, but many of them, like myself, were connected with some other section. I expressed myself, however, as in complete sympathy with the idea of having a section of historical chemistry.

As we returned from our seat to the Gymnasium, Professor Smith told me of his long years of service as Professor and Provost at the University of Pennsylvania and of how he had finally resigned his duties in order to devote his few remaining years to historical research.

BIRTH OF THE SECTION

It was on this occasion under a tree on the shore of Lake Michigan that Professor Smith first expressed to me his plan of establishing a History of Chemistry Section of the American Chemical Society. In the succeeding months we discussed matters further at occasional meetings and by correspondence. Professor Smith sounded opinion also among other chemists and finally decided there was support enough to launch the movement. The following extract is from my notes of the Rochester Meeting for April 27, 1921.

April 27, 1921

MEETING OF THE SECTION OF HISTORICAL CHEMISTRY AMERICAN CHEMICAL SOCIETY, ROCHESTER

Professor E. F. Smith called a meeting of those who were interested in historical chemistry in room 111 of the Mechanics Institute, 55 South Plymouth Avenue, Rochester, at 9:30 A.M. About 30 chemists were present, among whom were E. F. Smith, F. B. Dains, C. L. Parsons, Ellwood Hendrick, Victor Lenher, C. E. Coates, the Reverend Geo. L. Coyle, J. S. Chamberlain, G. B. Frankforter, F. J. Moore, F. O. Rice, W. T. Taggart, E. C. Franklin and C. A. Browne.

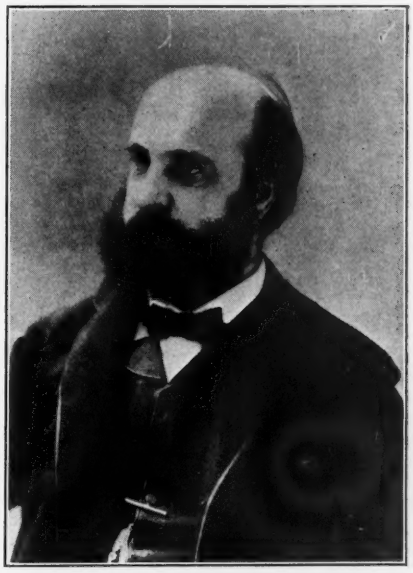
Professor Smith mentioned that he and Dr. C. A. Browne had organized the first meeting of the historical section at Evanston, Ill., under the shade trees of the Campus of Northwestern University on the shore of Lake Michigan during the meeting of the American Chemical Society at Chicago in September, 1920. At this little meeting the two members told each other about their collection of autograph letters, portraits, etc., of Priestley, Silliman, Davy and other chemists, and enjoyed a very pleasant exchange of views about the history of chemistry, more particularly of chemistry in America. The discussion was such a delightful one that steps were taken to invite other chemists to take part in a similar gathering at Rochester, and to start the present meeting. The two charter members had brought with them a small collection of interesting books and autograph letters for inspection.

Professor Smith then showed the members an old Latin alchemical treatise which had at the end the words: "Praise be to God, the keeper of the earth." This termination reminded him of an incident connected with the visit of Sir William Perkin to this country some 15 years ago. The aged chemist in closing an address upon his discoveries to the students of the University of Pennsylvania said with up-lifted hands: "Praise be to God to whom belongs all the glory."

Professor Smith then passed around among the members a book containing autograph letters of Berzelius, Cooper, Hare, Davy, Chaptal and other chemists. He also distributed photographic copies of the coat of arms of Joseph Priestley, which bore the motto: *"Ars longa Vita brevis,"* and which was used by Priestley as a book plate.

Professor Smith then showed a photographic copy of a portrait of W. W. Mather, a descendant of Cotton Mather and a professor at West Point. Mather's determination of the atomic weight of aluminum in 1835 was probably the first atomic-weight work done in the United States.

Professor Smith then spoke of various books upon chemistry written by American authors. He mentioned particularly "The Elements of Chemical Science" in two volumes written by John



HENRY C. BOLTON

Gorham, professor of chemistry at Harvard from 1816–1827. He spoke of the book as being very rare and difficult to find, the only copies to which he had access being in the Pennsylvania State Library at Harrisburg. Another old treatise was John White Webster's "Manual of Chemistry." Webster was professor at Harvard after Gorham, and came to a most unhappy end. He was convicted of the murder of Dr. Parkman and hanged November 23, 1849. Professor Smith spoke of Webster's strong anti-religious feelings and of his erasing the name of the second person of the Trinity from his books.

Dr. C. A. Browne in beginning his remarks said that a statement made by Professor Smith in his recent book, "Priestley in America," that "the time had come in reviewing the development of chemistry in this country when everything from the very first happening should be laid upon the table for study and reflection," might be taken as a suitable motto for the work of the new historical section.

Chemistry in America had in fact a history of nearly 300 years. In 1631, John Winthrop, the younger, brought from England numerous books upon chemistry and alchemy, a collection to which he added up to his death in 1676. Some 60 or more of

Winthrop's chemical books, comprising works by Glauber, Becher, Basil Valentine, and other writers, many of them annotated in Winthrop's handwriting, are preserved in the New York Society Library and they constitute without doubt the oldest chemical library in the United States.

In 1646 the celebrated alchemist Geo. Stirk or Starkey graduated from Harvard. He set up a laboratory and furnace in Boston, one of the earliest of which we have record. From this time alchemy has an unbroken history in America for almost 200 years. The act of transmutation has been reported in cities extending from Salem, Mass., to Savannah, Ga. One of the last accounts is of an alchemist named Lichenstein who practised his art on Wall Street, New York, in the early part of the last century.

Joseph Priestley.

BOOK PLATE

Among the earlier writers of chemical books in America, Dr. Browne mentioned Amos Eaton, a pupil of Benjamin Silliman, who wrote the "Chemical Instructor," published in Albany, 1822, and Joel B. Nott, Professor of Chemistry in Union College, who wrote a "Syllabus of a Course of Lectures on Chemistry," published in Schenectady, 1825. Nott's table of metals contains 42 names, among them the metal Wodanium. Among other elements, Nott mentions carbon, phosphorus, sulfur, hydrogen, nitrogen, oxygen, chlorine, iodine, fluorine, and the two imponderable bodies, light and caloric. Copies of these two books were shown.

The American press was busy 100 years in striking off reprints of foreign chemical books. This was before the day of copyright laws and American editions appeared in some cases only a few weeks after the English books were off the press. An English edition of Accum's "Treatise on Adulterations of Food" dated 1820, and an American edition of the same book published the same year in Philadelphia by Abraham Small were shown. The title page of the English edition has an engraving of a human skull resting on an urn upon which is the inscription "There is *Death* in the Pot." It was from this that Accum derived his nickname of "Death in the Pot."

Frederick Accum is noted as being one of the earliest teachers of American students, among whom were Benjamin Silliman, professor of chemistry at Yale, J. F. Dana, afterwards professor of chemistry at Dartmouth, and Mr. Peck, afterwards professor of natural philosophy at Harvard. An artistic card, representing Saturn, the patron deity of Chemistry, used by Mr. Peck as a ticket to Accum's lectures, was shown and also a photograph of Accum's old laboratory building, now a tailor shop, as it exists in Compton Street, London, today.

In addition to teaching chemistry, Accum did a large business as a dealer in apparatus and chemicals. He fitted up many college laboratories in the United States between 1800–1820. A bill for apparatus and chemicals sold by Accum to Professor Peck of Harvard in 1808 was exhibited. It comprises about 75 items, such as retorts, receivers, funnels, mortars, tubing, crucibles, furnaces, blow-pipes, etc., with prices. The most surprising feature of this bill is the item "$\frac{1}{2}$ *oz. pure platina in slips 4 shillings*," which is about 7¢ a gram.

A portrait of Accum was shown which represented him as holding a piece of apparatus, of which he invented many types. Accum published some 20 books upon chemistry and chemical technology. He wrote the first book upon gas-lighting, the first book on food adulteration and the first English work on crystallography. He published other works on chemical amusements, chemical tests, chemistry of brewing, breadmaking, cooking, etc. His works were in great demand for many years and were translated into various foreign languages.

Accum did more than any other chemist of his time to popularize chemistry, and his lecture hall was always filled. He suffered the most tragic fate that can befall a scientist—that of going into sudden oblivion with a clouded reputation. His exposures of food adulterations in 1820 had aroused the anger of the perpetrators of such practices, and he was made the victim of a malicious charge of stealing pages from the books of the Royal Institution. Although acquitted, his enemies stirred up public opinion against him to such a degree that he finally went from England to Germany where he ended his days. Thirty years after Accum's death, Dr. Hassal resumed the fight against food adulteration and, his predecessor having paved the way, succeeded in passing the first of the modern Food and Drug acts.*

THE REV. GEO. L. COYLE

Dr. Browne spoke of Benjamin Silliman's relations with European scientists, and as an example of this, exhibited a letter written by Samuel Parkes to Silliman in 1823, in which he thanked Silliman for having been instrumental in procuring an honorary degree for him from Yale. Parkes was a well known technical chemist in England and the author of numerous works on chemistry. In speaking of Silliman, Dr. Browne mentioned that Yale University Library contained over 15 manuscript volumes of his journals and memoirs all of which are invaluable in studying the development of chemistry in this country between 1790 and 1860. Silliman gives in them his experiences and opinions as a student, teacher and lecturer of chemistry and as a consulting chemical expert. This material is of incalculable value to the history of chemistry in America and it should be edited by some members of the American Chemical Society in coöperation with the library of Yale University.

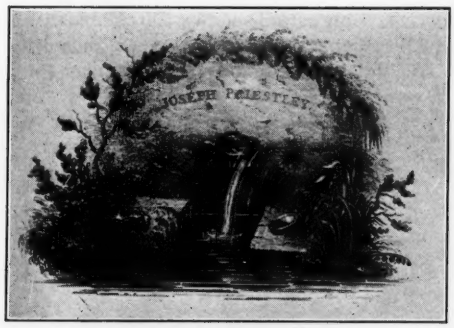
Dr. Browne, in concluding his remarks, distributed among the chemists present photographic copies of the book plate of Joseph Priestley described by him in the *Journal of Industrial and Engi-*

* See BROWNE, "Life and chemical services of Frederick Accum," J. CHEM. EDUC., **2**, 829–51 (1925).

neering Chemistry for June 1920. He also exhibited autograph letters and engravings of Silliman, Rumford, Priestley, Davy, and Dalton. A miniature portrait of Joseph Priestley painted upon ivory, a lock of John Dalton's hair and an early copy of Dalton's "Experimental Essays on Mixed Gases," with his diagrams of simple and compound atmospheres, were also shown.

Dr. C. L. Parsons exhibited a copy of a rare early work by Dalton upon Chemistry.

Dr. F. B. Dains described briefly a collection of rare old chemical and medical books which he had seen in the library of Transylvania University in Lexington, Ky. He believed that many of these books belonged originally to Thos. Cooper and thought the collection should be studied and examined.



BOOK PLATE

Mr. F. O. Rice of New York University gave an interesting account of the experiments made by Professor John W. Draper when he took the first portrait of a human face by photography, which was a daguerreotype of his sister. Her face was powdered with white chalk to increase the reflecting surface, and exposure was made in the direct sunlight. On account of the formation of deep shadows under the eyebrows and chin, the sitter was then placed under a thin canopy and the shaded parts of the face were illuminated by reflecting mirrors.

A younger member asked Professor Smith if the work of the historical section of the American Chemical Society might go so far afield as Mexico. Professor Smith replied by saying that it should cover the whole Western Hemisphere. The younger member then spoke of the work of a Spanish chemist named Del Rio in Mexico, over 120 years ago. Del Rio was interested in mining and seems to have possessed an unusually well equipped laboratory. He discovered in a lead ore from a Mexican mine the element vanadium. Although the discovery was ridiculed at first and Del Rio, from feelings of modesty, did not press his claims, his work was confirmed some 30 years later by Sefström and also by Wöhler and Berzelius. The speaker thought the historical section might do a good piece of research in uncovering the forgotten life and work of this pioneer Spanish chemist.

The Reverend G. L. Coyle stated that he had a well educated Mexican who was working in his laboratory at Holy Cross College, Worcester, Mass., and he would have him look up the history of Del Rio.

Dr. F. B. Dains expressed the opinion that it might be well for the American Chemical Society to publish historical monographs upon certain topics of interest to chemists in the United States. Professor Smith feared the interest in historical chemistry in America was not as yet sufficiently widespread to create a demand for such monographs.

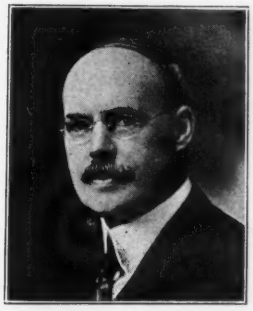
Another member spoke of the pleasure which he had derived from reading the old letters of Priestley, Davy, Dalton, Chaptal, and other celebrated chemists that were shown in the meeting and said that all such interesting documents should be photographed so that if the originals were lost a duplicate might be preserved.

Professor C. E. Coates asked if it was desired to organize the section of historical chemistry upon the same basis as other sections and divisions of the American Chemical Society. Professor Smith thought it better not to force the movement, but to let things develop freely and spontaneously. Those who were interested could meet at each meeting for a friendly exchange of views; if any member had something of interest to show, let him bring it along; the program of each meeting would thus shape itself and as so carried out would probably be of more interest than a prearranged schedule of papers.

Professor E. C. Franklin spoke of the researches which his colleague, Professor John M. Stillman of Stanford University, had made in historical chemistry, and mentioned the book upon Paracelsus which Professor Stillman had recently published. He regretted that Professor Stillman could not attend this meeting, as the subject of historical chemistry was one in which he had always been greatly interested.

After a few remarks by Prof. F. J. Moore and Professor G. B. Frankforter upon the value of studies in historical chemistry, the meeting adjourned at 11:30 A.M.

The keynote of this first Rochester meeting of the History of Chemistry Section, as emphasized by its chair-



L. C. NEWELL

man and organizer, Dr. Smith, was investigation of the history of chemistry in America. This, in his opinion, was to be the chief, although by no means the exclusive, aim of the section, and he was always anxious that a goodly number of papers upon some phase of chemistry in America should appear upon our programs. I fear that we have strayed at times from this original ideal of Dr. Smith in arranging our programs. There is nothing better which we can do in a constructive way toward promoting the work of this Division than in having always some papers upon phases of the history of chemistry in America. The field of inquiry is so large, and so much of it is unexplored, that it should attract a large band of our younger members.

HEAVY TOLL OF DIVISION MEMBERS

Looking back over the sixteen years since the time of our first Rochester meeting we are overwhelmed when we count the heavy losses of members who did so much to make this Division a success.

Dr. Edgar F. Smith, our first chairman, the organizer, founder, and inspiring leader of everything that we accomplished during those first eventful years. Those who knew him were indeed fortunate for he was the best-loved chemist of our Society and one of the greatest chemistry teachers of his time.

Dr. Lyman C. Newell, another chairman, whose enthusiasm and industry could always be depended upon in the organization of our exhibits and programs. Like Dr. Smith he was a tireless collector of old books, prints, letters, and other chemical memorabilia. How fortunate that the devoted wives of these departed colleagues have perpetuated their memories by the establishment of their husbands' priceless collections as permanent memorials in the universities which they served so long!

Father George Coyle, another founder and supporter of the history of chemistry movement. He was one of the most warm-hearted men whom I have ever known. It was a joy to be in his company. He did much for the success of this Division and would have done much more except for the heavy burden of administrative duties in building up the chemistry department of his university.

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To these five chemists should be added also the names of Professors B. B. Ross, Philip E. Browning, and J. N. Swan who, although not founders, were active supporters of the work of our Division and contributed interesting papers to several special programs. Among the departed should be mentioned also the names of Dr. E. C. Franklin, Dr. Elwood Hendrick, and Dr. E. E. Slosson who, although not contributors of papers, were warm supporters of our work and frequent attendants at our meetings.

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There was much work conducted by a few of us in the early history of this Division which did not appear on the programs of our meetings and it is to several of these unlisted, yet highly important, activities, which were planned at occasional conferences and by correspondence, that I wish to refer at the present time.

PRIESTLEY HOUSE AND MUSEUM

The life and work of Dr. Joseph Priestley in America were subjects very dear to the heart of Dr. Smith and were discussed at our conference at Evanston in 1920 and at the Rochester meeting in 1921. He was anxious to perpetuate the memory of Priestley in definite, tangible forms. Hence his little book upon "Priestley in America," and hence his activities in raising subscriptions for a portrait of Priestley, which was unveiled at the New York meeting of our Chemical Society in September, 1921, and then deposited in the gallery of the National Museum.

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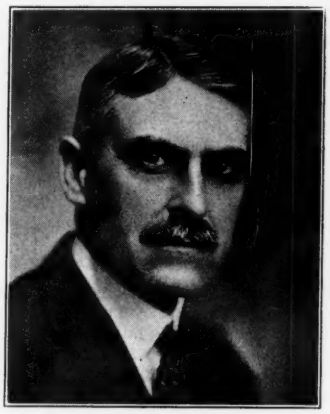

WILLIAM FOSTER

G. G. Pond, to whose quick initiative, in buying the historic house when it was sold at auction, we owe its preservation.

The original trustees of the Chemical Alumni of State College for the Priestley House in Northumberland were Dr. W. H. Walker and Mr. W. H. Teas, who frequently consulted with Professor Smith and the writer at various meetings of the American Chemical Society regarding plans of organization. I quote from my journal for the meeting of the American Chemical Society in New York for September 6, 1921.

At the Council Meeting President Smith spoke about the Priestley House in Northumberland and the efforts that were being made to preserve it on its present site. After the Council meeting I met W. H. Teas, a Pennsylvania State graduate, whom I once taught qualitative analysis. I introduced him to President Smith with whom he wished to discuss the proper disposition of the Priestley House. Teas said he held the property for the Pennsylvania State Alumni. He sent Professor Pond a $6000

check to buy the house and subscriptions had been received to cover $4000 of this. Professor Pond wished to move the house to State College and the Linde Air Products Company had consented to do this but Pond's death and the extreme cost ($25,000) for moving the building and re-erecting it caused this company to withdraw their consent. Teas agreed with Professor Smith and me that the building should not be moved but repaired and fitted up as a Priestley memorial. He feared the opposition of Mrs. Pond who felt that her husband's wishes should be performed. President Smith and I told Teas that we and many others would be ready to give our Priestley relics to establish a museum in the house provided it be not moved.

A later conference, which I had with Dr. Walker, indicates the developments which were taking place regarding the preservation of the Priestley House. I quote from my journal for April 21, 1922.

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(Showing Priestley's laboratory in the "L.")

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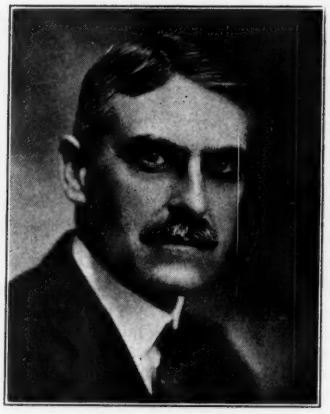

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DEDICATION OF THE JOSEPH PRIESTLEY MEMORIAL, SEPTEMBER 5, 1926. TAKEN FROM THE ROOF OF THE MUSEUM; DR. CHARLES A. BROWNE SPEAKING

of its secretary, Dr. Spencer Baird, who, in a letter of April 24, 1883, promised the widow of Dr. Joseph Priestley, 3rd, "If you will intrust this apparatus to the Smithsonian Institution, it will be accorded a prominent place in the historical department of the National Museum where it can be exhibited and appreciated in a thoroughly fire-proof building." In a letter, dated April 28, 1883, to Miss Frances Priestley of Northumberland (the late Mrs. Frances P. Forsyth), Secretary Baird expressed his appreciation of the donation of the Priestley apparatus to the Smithsonian Institution and furthermore stated, "I have promised permanent and secure preservation, and the fullest possible prominence, so far as well-lighted cases and large and legibly-printed labels will go." To the great grief of the Priestley heirs these promises of Secretary Baird were never carried out. The apparatus was not only unexhibited but it remained neglected for over forty years in a basement of the Smithsonian Building in Washington. On November 24, 1926, I wrote a letter upon the subject to Dr. W. deC. Ravenel of the National Museum, from which is quoted the following passage.

"Doctor Joseph Priestley at the time of his death in Northumberland, Pa. in 1804, was not only one of the best-known scientists of the world, but he had unquestionably the best-equipped scientific laboratory in the United States. In this laboratory he made discoveries which have been of the greatest importance to science, and it is only fitting that the few remaining pieces of his scientific apparatus should be carefully preserved in a suitable exhibition case instead of being carelessly placed as they are at present upon window ledges and boxes in a basement of the Smithsonian building. The apparatus when I saw it was scattered about among tables, cases, patent models, and other miscellaneous material, where it might easily be broken by workmen. There is also the risk that the identity of the various pieces of apparatus may be lost, or that other foreign material through mistake may become incorporated with the Priestley apparatus unless the latter is carefully segregated and kept in a case by itself. It seems to me that the apparatus of Priestley is one of the most valuable scientific collections in the whole National Museum and that it should be given a place of honor, where it can be seen by the scientists who come to Washington from all parts of the world, instead of being allowed to remain in its present neglected state. In my opinion the various chemical, physical, electrical, and astronomical pieces of apparatus in this collection should be carefully examined by a committee of competent scientists, the scattered parts of the various apparatus restored and the whole assembled for exhibition.

"If there is not space at the Museum for the suitable installation and exhibition of the Priestley apparatus, I would suggest that the collection be loaned to the Priestley Museum, which has recently been erected and dedicated at Priestley's old home at Northumberland, Pa. This museum is a beautiful brick building of fire-proof construction and stands within a few feet of the old house erected by Priestley himself. The Priestley house and museum are under the care of a custodian living upon the premises and are to be preserved as a permanent memorial. The museum contains apparatus, manuscripts, books, portraits, and other memorabilia of Priestley. Many people who own Priestley relics have generously donated their material to the Northumberland museum, and the collection deposited with the Smithsonian should, in my opinion, be transferred there to its original home

where it will be well preserved, rather than to remain in its present neglected condition."

The suggestion contained in this letter was adopted by the authorities of the National Museum and in 1927 its collection of Priestley apparatus was transferred as an indefinite loan to the Priestley Museum in Northumberland. But as matters developed this transfer of Priestley memorabilia to their original home, while most appropriate for sentimental reasons, was premature. Well-intentioned people in their efforts to improve things often make matters worse, and this seems to have always been the case with those who have tried to make provision for preserving the historic relics of Priestley. The museum building at Northumberland, as originally constructed, was not well protected against the penetration of frost and dampness. Old books were injured by moulds, while two magnificent old globes of Priestley were so damaged by mildew that the surfaces of these precious mementos were completely ruined. It was to prevent such consequences of neglect that the original plan of a joint directing committee was broached by the first trustees of the museum to the owners of Priestley memorabilia. The deaths of these trustees (Mr. Teas, the financial supporter of the museum project, and Dr. Walker, the scientific advisor) caused a lapse in some of the plans and the remoteness of Northumberland did not insure that constancy of inspection which is so necessary for the upkeep of a museum.

JOSEPH PRIESTLEY MUSEUM FROM THE SOUTHWEST

According to a statement in the *Science Leaflet* for September 17, 1936 (page 6), the Priestley property in Northumberland is to be cared for by a Board of Trustees appointed by the Pennsylvania State College and "by a number of organizations including the American Chemical Society, the American Philosophical Society and the Pennsylvania Historical Society." This statement is fully in accord with the early plan of organization approved by the two trustees of the Pennsylvania State College Alumni, and by Professor Smith and the writer, the coöperating members of the History of Chemistry Division. It is hoped that an announcement by the Pennsylvania State College will confirm the published statement in the *Science Leaflet* and thus help to reassure the minds of those who have the permanent preservation of Priestley's scientific apparatus and manuscripts so much at heart.

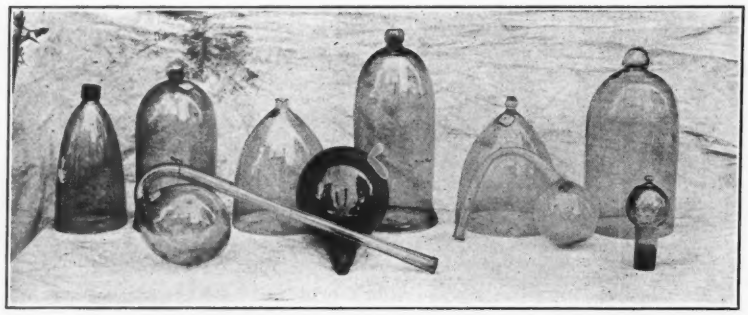
The occurrence of unprecedented high floods on the Susquehanna River in March, 1936, caused four and one-half feet of water to enter the cellar of the Priestley house. The inundation came up to the foundation of the museum building and the rise of another foot might have undermined its walls with a collapse that would have meant the complete destruction of its contents. The possibility of damage to the contents of the museum by future recurrences of high water must be carefully considered by the Museum authorities, who should make provision, in time of threatening floods, for removing objects of historic value to a place of safety. The Priestley apparatus at Northumberland, Pennsylvania, like the John Winthrop collection of old chemical books in the Society Library of New York City, are historical possessions that are precious to every American chemist. One of the main objects of this Division should be to take an active interest in the adequate preservation of our chemical landmarks for the benefit of future generations.

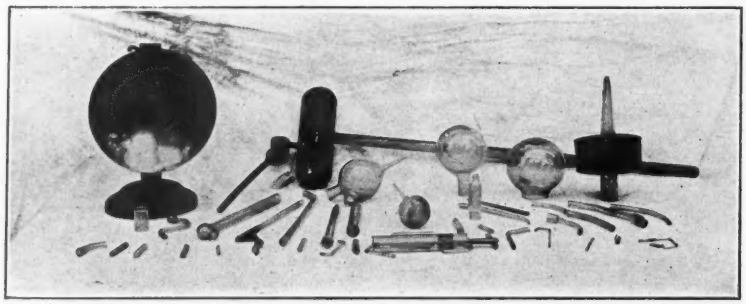
In commemoration of the two hundredth anniversary of the birth of Priestley, an historical exhibition of books, letters, and prints was displayed in the Library of Congress at the eighty-fifth General Meeting of the American Chemical Society in Washington in March, 1933. The exhibition, which was prepared by coöperation of representatives of the History of Chemistry Division with the Library of Congress, was so popular that it was extended for nine months. It did much toward popularizing the history of chemistry, and our members could help to widen the influence of this Division in no better way than by arranging similar exhibits in commemoration of famous chemists in their respective localities.

JOURNAL FOR HISTORY OF CHEMISTRY

A project very dear to Dr. Smith, in the last years of

his life, was the establishment of a journal of historical chemistry which was to be the official organ of this Division just as the JOURNAL OF CHEMICAL EDUCATION which he was instrumental in helping to establish, became the official organ of the Chemical Education Division. I quote from my minutes of the Birmingham Meeting of the American Chemical Society for April 3, 1922.





SOME OF THE PRIESTLEY APPARATUS FORMERLY IN THE NATIONAL MUSEUM

"Professor Smith asked if I thought there were members enough in the American Chemical Society to support a Journal for Historical Chemistry. I told him I did not think over one per cent. of the membership had an interest in the historical side of the subject and this would only amount to about 150 members. If the subscription price could be placed low enough, possibly a larger number would subscribe. Professor Smith thought he might get sufficient money to endow such a journal and the price could be made a nominal sum of two or three dollars a year. He said such a journal was needed to publish the researches of the historical section and to stimulate interest in the subject. He admitted that only a few chemists were interested in historical chemistry. If chemists called at his office and he ventured to point out Priestley's balance or some other object of historical interest the response was usually an amused smile and nothing more."

Another citation for the meeting at New Haven on April 4, 1923, is to the same effect.

"Professor Smith told me that he had asked W. H. Nichols for $100,000 to start an American Journal of Historical Chemistry and believed that he might be successful. This journal was a proposition which he had always in mind. It was needed for the publication of the numerous papers presented before the meetings of our historical section and for which there was no present outlet. Professor Smith said if the plan was successful it would be the only journal devoted purely to the history of chemistry in existence. The *Chemiker Zeitung* and some other European journals published an occasional article of historic interest, but there was no journal which made historical chemistry its main object.

"Professor Smith said that after his return to Philadelphia he intended to write out a statement of his ideas upon the subject which he would send to me for criticism. He would then put the matter in definite form before certain influential members of the Society. He considered a historical journal to be one of the greatest needs of American chemistry."

At the Richmond meeting on April 13, 1927, and at subsequent times Professor Smith referred again to the same subject. He said that to have the first copy of such a journal placed in his hands would be the realization of one of his fondest hopes. In the opinion of Dr. Smith a journal of historical chemistry would be the most effective means of emphasizing the great cultural value of chemistry and of resisting its present exceedingly materialistic trends. Our Division, I think, should always keep before it the possibility of bringing this long-deferred hope of Professor Smith to accomplishment. *Ambix*, the new English journal of the "Society for the Study of Alchemy and Early Chemistry," the first issue of which appeared in May, 1937, is a history of chemistry publication that serves as an example of what might be accomplished, although the scope of this journal is different from what Professor Smith had in mind.

The need of such a journal is especially apparent when we consider how few of the papers presented at our meetings are published. The manuscripts of these papers, many of which represent a vast amount of original research, become mislaid or destroyed and thus material of great historical value is lost. I will only refer in this connection to a valuable paper by the late Father Coyle, one of the founders of our Division, upon chemical information contained in the "Relations" of the early Jesuit missionaries. Father Coyle spent a vast amount of time exploring the many ponderous volumes of the "Relations," and the chemical material which he gleaned constituted a paper of great historical interest and value. The paper was never published and later diligent search, in response to inquiries, has failed to discover a copy of the manuscript. Many other cases of a similar character can be cited. In order to prevent such occurrences from arising in the future, I would like to suggest that copies of all unpublished papers read before this Division be deposited for safekeeping and future reference with the Edgar Fahs Smith Memorial Collection at the University of Pennsylvania. Users of such material would, of course, give the same

credit for their sources of information as in the case of published articles.

FIFTIETH ANNIVERSARY PROGRAM

The historical program for the fiftieth anniversary of the American Chemical Society was entrusted to a committee of this Division consisting of C. A. Browne, chairman, George L. Coyle, F. B. Dains, L. C. Newell, and Edgar F. Smith. The committee considered the best means of commemorating the Semicentennial of the Society to be the publication of a special issue of the *Journal* which should give (1) accounts of the origin, foundation, and development of the Society by some of the members who took an active part in these early movements; (2) a general statement of the activities of the Society; and (3) review of the progress in various branches of chemistry in America during the half-century of the Society's existence.

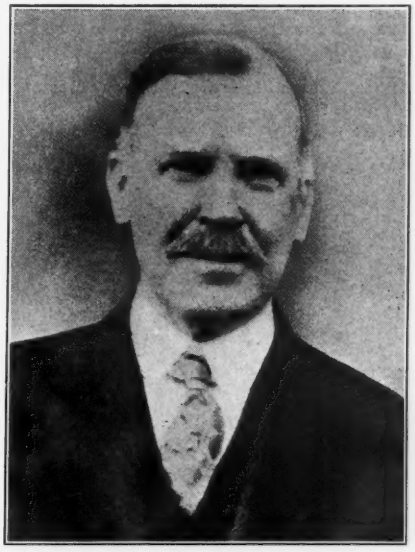
The outcome of these efforts was an historical volume of two hundred fifty-six pages entitled, "A Half-Century of Chemistry in America 1876–1926." The reviews of progress in various branches of chemistry in America related to accomplishments in mineral, physical, inorganic, organic, physiological, agricultural, and educational chemistry. The record was far from complete and the preparation of similar reviews in the fields of analysis, apparatus, biology, chemical constants, pharmacy, pharmacology, and other branches of chemistry, in which American scientists have won distinction, might well be undertaken by members of our Division.

CHEMICAL BIOGRAPHIES

Among other worthy accomplishments of this Division, in the sixteen years of its existence, have been the additions which our members have made to the biographies of American chemists—Winthrop, Starkey, Rumford,[1] Mitchill,[2] Griscom,[3] Gorham, Silliman,[4] Hare, Cooper,[5] Booth, Beck, Wetherill,[6] Gibbs,[7] Clemson,[8] Pugh,[9] Bancroft,[10] and many other native, or adopted, Americans have had their accomplishments presented at our meetings. A number of the sketches of prominent chemists in the new "Dictionary of American Biography" were written by members of our Division. It is hoped that we may have biographical sketches of other American chemists, prominent in their day but now nearly forgotten, included in our future programs. I would mention such names as Oliver P. Hubbard, Eben N. Horsford, John A. Porter, C. A. Joy, G. C. Caldwell, Thomas Antisell, T. Sterry Hunt, and F. H. Storer.

TECHNOLOGICAL ORIGINS

Accounts of early alchemy and of medical chemistry in America have been told at our meetings and the history of several colonial chemical industries, such as iron, potash, naval stores, indigo, sugar, salt, and leather, has been presented in a number of contributions. There is a great need of continuing investigations in this field. We must get back to the first origins of our petroleum, soap, fertilizer, explosive, dyestuff, cement, metallurgical, pharmaceutical, essential oil, and numerous other chemical industries. At the Pittsburgh meeting of our section in 1922 the late Dr. Matthews, President of the Crucible Steel Co., gave a paper upon the origins of the iron industry in America which showed us what splendid work an expert technologist can do when he enters the historic field.



B. B. Ross

To those of you who are interested in technological origins I would mention two recent works that are of special value. One of these is a book edited by Professor E. M. Coulter and published by the University of North Carolina Press, entitled, "Georgia's Disputed Ruins" which throws much light upon the early sugar industry of that state. The other is a seventy-page booklet, entitled, "The Early Iron Industry of Connecticut," by H. C. Keith and C. R. Harte, published first in the Fifty-first Annual Report of the Connecticut Society of Civil Engineers, which gives an account of

[1] NEWELL, "Count Rumford—scientist and philanthropist," *Science*, **68**, 67–73 (1928).
[2] HALL, "A chemist of a century ago," J. CHEM. EDUC., **5**, 253–7 (1928).
[3] DAINS, "John Griscom and his impressions of foreign chemists in 1818–19," *ibid.*, **8**, 1288–310 (1931).
[4] BROWNING, "Benjamin Silliman and the beginnings of chemistry at Yale," *ibid.*, **11**, 170–4 (1934).
[5] ARMSTRONG, "Thomas Cooper as an itinerant chemist," *ibid.*, **14**, 153–8 (1937).
[6] SMITH, "Charles Meyer Wetherill, 1825–1871," *ibid.*, **6**, 1076, 1215, 1461, 1668, 1916, 2160 (1929).
[7] JOHNSTON, "Willard Gibbs, an appreciation," *ibid.*, **5**, 507–14 (1928).
[8] BRACKETT, "Thomas Green Clemson, D.D., the chemist," *ibid.*, **5**, 433–44 (1928).
[9] BROWNE, "European laboratory experiences of an early American agricultural chemist—Dr. Evan Pugh (1828–1864)," *ibid.*, **7**, 499–517 (1930).
[10] BROWNE, "A sketch of the life and chemical theories of Dr. Edward Bancroft," *ibid.*, 103–7 (1937).

early iron manufacture in Western Connecticut and the neighboring parts of New York and Massachusetts. A search of the Archives of our State Historical Societies, old State and County Gazetteers, and the files of old magazines and newspapers will bring to light many forgotten facts of chemical interest. Abstracts which I have had made from the *Hampshire Gazette* for 1836 and the years following have yielded much information upon the origin of the first beet-sugar factory in the United States at Northampton, Massachusetts.

The development of methods of teaching chemistry in our American colleges has been illustrated at our meetings by references to lectures and by the display of old student theses and notebooks. This is a field in which much remains to be done. At our Pittsburgh meeting of a year ago there was shown an early notebook of chemical lectures taken under Professor Chester Dewey who taught first at Williams College and then later for many years at the University here in Rochester where Dewey Hall now commemorates his memory. An excellent oil portrait of this distinguished teacher of chemistry can be seen in the Library of Rochester University.

E. C. FRANKLIN

I have brought with me today another student notebook of chemical lectures taken under that doughty physician and teacher, Dr. William Macneven, whose career was filled with more excitement and adventure than fall to the lot of the average college professor. Much remains yet to be told about Macneven and his chemical contemporaries.

The history of early chemical apparatus in America has been briefly referred to in several papers presented before our Division. In response to the mention of the need for writing up the story of the origin and development of the chemical apparatus business in America, made by the writer at our Buffalo meeting six years ago, several experts connected with supply houses have investigated certain sections of this field in their leisure time and it is hoped that we may soon have a treatise upon the subject. It is a pity, however, that this was not undertaken a quarter of a century or more ago, before the passing of so many of the pioneers in the manufacture of chemical equipment. We need a general stock-taking of the old discarded pieces of early apparatus in the laboratories and museums of our colleges and universities. Unfortunately, much material of early historic value has been thrown away as worthless.

EDWIN EMERY SLOSSON

Closely connected with the history of chemical apparatus and of chemical industries in America is the story of the origin and development of analytical and consulting laboratories. Professor Smith told us once about the early analytical laboratory of James C. Booth and Martin Boye in Philadelphia, which has had a continuous history of over one hundred years. Equally old was the famous analytical laboratory of Charles T. Jackson in Boston, visited so often by Ralph Waldo Emerson. The story of Jackson and his laboratory remains to be told at one of our future meetings.

Jackson belonged to that famous group of early state geologists consisting of such men as Gerard Troost of Tennessee, Ebenezer Emmons of New York, David Owen of Indiana, and Robert Peters of Kentucky, who were equally skilled in chemistry, geology, botany, and medicine, and whose early reports upon the chemical resources of their respective states contain much of theoretical and practical value. A full half-century before the establishment of our Agricultural Experiment Stations they were the first to undertake a systematic study of the soils and crops of the United States. They were our earliest agricultural chemists. The chemical achievements of each one of these pioneer American investigators deserve to be considered at some of the future meetings of our Division.

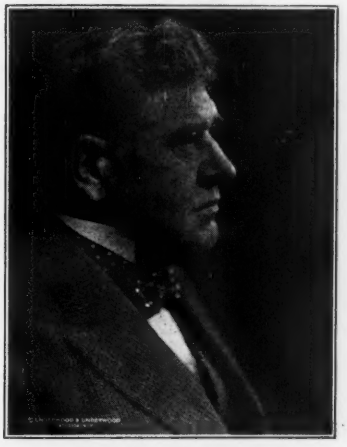
MISCELLANEOUS ACTIVITIES

A subject occasionally referred to by Professor Smith at the first meetings of our Division was the preparation of a bibliography of early American textbooks upon chemistry. This is a project well deserving of the labors of some member of our Division who has access to a well-equipped scientific library. To a listing of the early chemical books published in America before the Civil War might be added a survey of the early medical, technological, and other scientific journals for articles published by American chemists and also a search of the indexes of the U. S. Patent Office for the compiling of a list of early chemical patents. A classification of such patents according to title for different years would throw much light upon the early development of some of our chemical industries.

I have limited this discussion of the Past and Future of our History of Chemistry Division to considerations relating to Chemistry in America, for, as mentioned at the beginning, this was the main object of Professor Smith when he called us together at Rochester for the first time in 1921. Professor Smith was not averse, however, to including papers upon our programs which dealt with chemical developments in other countries, and he followed this practice himself in a number of his contributions before our Division. Because of their longer and more intimate relations with the origins of chemistry, it is only natural that developments in European countries should occupy the most conspicuous place in the history of this science and nothing could be farther from the views of Edgar Smith than to exclude from our program all papers that did not relate to Chemistry in America.

The historic fields of Chemistry in America and Chemistry in European countries need to be tied more closely together. The drift of American chemistry students to European universities began as far back as Colonial times and it has continued with only occasional breaks until the present. The stories of the contacts of American students with Black, Liebig, Wöhler, Mulder, Dumas, Bunsen, and other noted European chemists are filled with details of deep personal interest that deserve to be recorded. The narratives also of eminent European chemists, such as Draper, Troost, Goessmann, Wislicenus, and hundreds of others, who made America either their temporary or final home, will help equally well toward a closer binding of the international ties of friendship which seem now to be in greater danger of disruption than ever before.

The founder of our Division, Edgar Smith, never neglected the claims of theoretical or applied chemistry, but what he especially desired was to present with these other aspects of the science the great cultural and humanistic values of chemistry as exemplified in the lives and accomplishments of its great leaders. For the training of students who were to take their part in



ELLWOOD HENDRICK

the future of our Republic, he preferred without being partisan or provincial to cite as examples the lives of chemists who had been identified with the history of his own city, his own state, and his own country. As a discipline he believed that every student should acquire an historic approach to a subject and that this approach should be from what is near to what is more remote, from events at home to events abroad. In the same way with historical research he felt that the student's interest would be more vital and his civic pride more intense if he first explored the chemical origins of his own locality. When this had been done he could be trusted to go farther afield.

This paper has dealt largely with some of my close personal relations with Dr. Smith in the early formative days of our History of Chemistry Division.* I have indicated some of the hopes which he had in mind when he called us together for the first time at Rochester sixteen years ago, but have utterly failed in picturing to you the greatest thing of all, which was the attraction of his wonderfully inspiring personality. It was chiefly this which filled our meetings, while he was with us. If we could only acquire something of his faith and spirit, the future of this Division would be secure.

* See Edgar Fahs Smith Memorial Number, J. CHEM. EDUC., April, 1932.

Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new. Yet nearly all the grandest discoveries of science have been but the rewards of accurate measurement and patient, long-continued labour in the minute sifting of numerical results.—LORD KELVIN

MINUTES OF THE MEETING OF THE EXECUTIVE COMMITTEE OF THE DIVISION OF CHEMICAL EDUCATION OF THE A. C. S.

The Executive Committee met in Rochester on Monday noon, September 6th, with the following present: O. M. Smith, Chairman; E. W. Phelan, Vice-chairman; N. W. Rakestraw, Secretary; Virginia Bartow, Treasurer; Otto Reinmuth, R. E. Swain, M. V. McGill.

The following report from the treasurer was read and approved:

REPORT OF THE TREASURER OF THE DIVISION OF CHEMICAL EDUCATION FROM APRIL 6, 1937, TO SEPTEMBER 1, 1937

Cash in Bank April 6, 1937	$479.65
Receipts from dues	28.00
Check returned from H. E. Howe	4.46
Total	$512.11
Expenditures	
H. E. Howe for abstracts	4.46
Spaulding Moss and Co. Abstracts of papers April, 1937	10.85
Total	$ 15.31
Receipts less expenditures	$496.80
Outstanding check	1.34
Cash on hand September 1, 1937	495.46
Cash in bank September 1, 1937	496.80

Respectfully submitted,
VIRGINIA BARTOW, *Treasurer*

Professor H. N. Holmes, of Oberlin College, was elected to the Board of Publication, to fill the place of R. E. Baker, retiring.

A question was raised concerning the revision of the committee program of the Division in the direction of the establishment of committees of more permanent character. No action was taken, but after some discussion the chairman and secretary were authorized to confer with the Committee on Naming and Scope of Committees concerning it.

N. W. RAKESTRAW, *Secretary*

MINUTES OF THE ANNUAL BUSINESS MEETING OF THE DIVISION OF CHEMICAL EDUCATION

The business meeting of the Division was held on Tuesday afternoon, September 7th. The following new officers were elected:

B. C. Hendricks, *Chairman*
M. V. McGill, *Vice-chairman*
A. J. Currier, *Member-at-large of the Executive Committee*

The report of the treasurer was read and approved.

Reports of the Committee on Tests and Examinations and the Committee on College Entrance Board Examinations were presented immediately preceding the business meeting, as papers on the regular program.

The Secretary was instructed to prepare suitable expressions of regret at the passing of John N. Swan and William Foster, long-standing members of the Division, and to send them to their respective families.

N. W. RAKESTRAW, *Secretary*

SECOND NATIONAL CONFERENCE ON EDUCATIONAL BROADCASTING

The Second National Conference on Educational Broadcasting to be held at the Drake Hotel in Chicago, November 29, 30, and December 1, will hear spokesmen for the radio audience, the radio industry, and education express their viewpoints on the problems and progress of educational broadcasting, according to an announcement by C. S. Marsh, Executive Secretary. Representatives of the Federal Radio Education Committee, the Federal Communications Commission, and the Office of Education Radio Project will report on government activity.

Visual evidence of accomplishments in educational broadcasting, and technical aids to broadcasting will be offered by educational and commercial exhibits. Exhibitors are urged to apply for space as early as possible to C. S. Marsh, 744 Jackson Place, N. W., Washington, D. C.

The Program Committee has outlined the following topics for the general sessions and section meetings, and will announce the speakers shortly.

MONDAY, NOVEMBER 29, 1937

10:00 A.M. General Session: The American System of Broadcasting
Presiding: George F. Zook, President, American Council on Education

2:00 P.M. Section Meetings: Talks Programs
What Happens to the Listener?
Office of Education Radio Program
Radio and the Child's Education

8:00 P.M. General Session: How Does Broadcasting Operate in the Public Interest, Convenience, and Necessity?
Presiding: Walter Dill Scott, President, Northwestern University.

TUESDAY, NOVEMBER 30, 1937

10:00 A.M. General Session: An Appraisal of Educational Broadcasting and Proposals for Improvement
Presiding: Robert M. Hutchins, President, University of Chicago

2:00 P.M. Section Meetings: Coöperative Radio Councils
Radio as an Art Form
Symposium of Listeners
Classroom Use of Radio

8:00 P.M. Banquet: Radio as a Present Day Force

WEDNESDAY, DECEMBER 1, 1937

10:00 A.M. Final Session: What Shall We Do with Radio?
Presiding, George F. Zook, President, American Council on Education

As a recognition of the formative stage of educational broadcasting, and its potential use in every conceivable educational field, the Conference has been opened to every individual who wishes to attend.

and SO YOU WANT *to* BE *a* CHEMIST*

JOSEPH J. JASPER

Wayne University, Detroit, Michigan

* EDITOR'S NOTE: This article originally appeared in the *Detroit Chemist*. Because it deals with a subject of perennial and general interest it is here made available to a wider circle of readers.

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". . . and so I want to be a chemist, and you have been appointed my adviser." The speaker, an eager youngster, thus brought to a close an animated account of his home-made basement laboratory and his experiments therein, his few precious pieces of apparatus, home-made and purchased, and his boundless enthusiasm. His young curiosity had been stimulated by certain chemistry demonstrations performed by his high-school teacher, he had become intrigued by the logic of the conclusions, and his enthusiasm had become aroused. And now he sat facing me across my desk, informing me of his desire to become a chemist, that my future duty would be to advise him, but my immediate responsibility was to suggest a course of study leading to that desirable end. Truly an important assignment—an additional load for my conscience. I recalled other years.

It was some twenty years ago that another youngster knocked at the portals of a certain mid-western university seeking to gain admission. He, too, was filled with youthful enthusiasm, and he, too, had the very worthy object in view of studying chemistry and becoming a chemist. "What a golden opportunity I have," he exulted, "what a privilege it will be to study under the direction of a venerable professor—to learn at the feet of the master."

The years passed quickly and graduation came for this young man. "Those venerable professors! Those masters of science! Where can they be?" he mused. "Perhaps I must seek further." Enrolment at other universities followed; the search for truth continued. Later, in the natural course of events, came advanced degrees and with them complete disillusion. Consult with the venerable professors! Study at the feet of the masters, indeed! Their counsel was unattainable and their persons as unapproachable as the North Star.

As in the past, so it is today in many of our "Temples of Learning." Where, then, are those inspiring men of wisdom, and what part do they play in the scheme of the education of youth? Since they teach but rarely, and then small, select groups, they can know but little of and care even less about the problems of teaching. Too often we see the "scholarly professor" busily engaged in research for his personal aggrandizement, while his students try in vain for his attention. Can there ever be complete mutuality in the professor-graduate student arrangement which exploits the student's time in gathering research data, after which he is awarded a degree? The granting of the degree usually constitutes the "finis" sign, for rarely afterward can the great man find time for his ex-student. He simply cannot be bothered; he must feverishly continue his data-gathering via other and later students; he must continue to grind out papers for publication—with his name signed thereon.

Who, then, must bear the burden of teaching in our colleges and universities? Convincing evidence points to the fact that this very important duty falls almost entirely upon the shoulders of the underpaid, overworked assistants. It is they who function as contact between the source of knowledge and the student. It is they who interpret for the student and thus pass on to him the knowledge that is so vital to the advancement of our civilization. For knowledge *is* the most important legacy that we can pass on. It is our one form of insurance whose value remains eternal. Research, with its concomitant accumulation of facts, must of necessity be attended by classification and correlation. This is often an arduous task. The facts thus discovered must be interpreted and disseminated, for knowledge out of circulation has no value to mankind. We can do no other than logically conclude that the dissemination of knowledge is equally important with its discovery.

And now in these latter years we hear persistent and growing voices from without the sheltered walls of the college and university, voices that demand attention, voices that must not be ignored. "Why is it," they inquire, "that you send these youngsters forth to us inadequately prepared to face real life, so distressingly deficient in common knowledge that they constitute a liability both in industry and in society? Where are those men of wisdom, those researching sages of education, who hold within their grasp the wisdom of the ages? How dare they neglect our youth, how can they justify their indifference?"

Those questions are truly important and constitute a direct challenge to our educational system, especially to the higher branches. Since they have not been answered, how, then, are they to be disposed of? Where does the fault lie? Are the teaching methods, the teachers, or institutional policies at fault? Probably all three. Would not a better correlation between

chemical theory and practice be obtained by the student if a better coöperation existed between men actively engaged in industry and the college teacher? Unfortunately, at present these two seem mutually to distrust each other. This coöperation could take the form of consultation between the two, or a series of lectures presented by men representing the various branches of applied chemistry, the latter being an integral part of the required course work. In any event, the teacher should be fully cognizant of the needs of industry and govern himself accordingly. To blindly ignore the challenge of these questions by refusing to recognize their existence is unadulterated folly. These questions are real and vital. Can our pedagogical theories be wrong? What constitutes good teaching?

The art of teaching, contrary to general opinion, is by no means simple nor easily acquired. That good teachers are born and seldom made is amply evidenced by their great scarcity, their abundance being quite on the order of hen's teeth. Teaching demands effort, again contrary to general opinion. The acquisition of learning is at best a painful process and resisted to the utmost by most human beings. This inertia must be overcome, and the good teacher is accordingly aggressive. A neutral, aloof, or indifferent attitude produces no results, for the teacher must put forth effort in order to inspire students to do likewise. The lazy teacher is worthless, now and forever.

To insure his keeping abreast of developments in his chosen science, a reasonable amount of research should be expected of the college teacher—provided the necessary adjustment in teaching load is made. This, however, should serve as a means to an end and not the end itself. To classify teaching ability in terms of published papers, the favorite pastime of some administrators, is pure nonsense. The active teacher rarely has time for research, while the individual doing research takes but little time for teaching. The two are governed by totally different philosophies. They exist in different worlds. Furthermore, research and teaching ability are rarely found together. Though both demand skill and patience, the human relation, so important in teaching, has no place in research. Regardless of his importance in education, the student has but little hope in the scientist who does pure research.

What of the institutional policies and their effect upon student training? Education has suffered greatly during the last few difficult years, and one attendant result was a serious curtailment of normal faculty expansion. This will continue to be a problem until the populace insists that the politicians, who directly or indirectly control the purse-strings, awake to the fact that education is more important than their henchmen and them. More and more students have been assigned to less and less teachers until teaching loads have become crushing. Quantity production with decrease in quality must necessarily follow such a procedure. This, together with the financial uncertainty of his position, has just about destroyed the morale of the teacher, the student receiving the very doubtful benefit attendant upon this state of affairs. Rarely paid adequately for his service, the teacher has carried on gallantly in the face of diminished income, diminished equipment, diminished free time, and increased enrolment. Huge teaching loads have never been conducive to good teaching, for the teacher is not a machine. He is entitled to humane treatment.

Fortunately, much of this is beginning to be recognized by the colleges and universities themselves. Some of our leading educational institutions, which formerly placed their sole emphasis on research ability, are now recognizing outstanding teaching ability as being equally important. Promotions in academic rank and the award of honors have been made independently for both of these desirable qualities. Good teaching is thereby encouraged, and the student will consequently benefit.

What are the specific faults found by men who employ chemists? What qualities do they desire in their employees? At the recent meeting of the American Chemical Society in Pittsburgh, five representative employers of chemists voiced their opinion regarding the necessary qualifications of a good chemist.* The list of requisites was truly illuminating. It includes a thorough knowledge of his subject; ability to initiate his own work and carry a problem to completion; ability to search scientific literature, record his results, write his reports, present his side of the question to inquiring directors; neatness and accuracy; considerateness of his "superiors, equals, and inferiors"; kindness to associates in the same work or in allied fields; a decent disposition. The chemist should have "horse-sense," be a good team-worker, aggressive though not "cocky," be fair in his relations with others, ask for help, give credit when and where due, coöperate. He should be intellectually honest about his work, critical of his findings, loyal to his assignments, adaptable to changing environments, and not take himself too seriously. Beside these excellent qualities, many others were mentioned as being highly desirable.

Examination of these requisites quickly convinces one that the demands of the employers are considerable. One is inclined to ask, however, about their willingness to pay for these desirable qualities. Are they willing to pay salaries commensurate with these abilities? Are they willing to insure a reasonable degree of permanence of employment, so that the chemist will not be the first to bear the brunt of hard times? Are they, in turn, willing to "give credit when and where due" and "show a decent disposition"? Are they willing to develop the high sense of idealism and loyalty demanded of their employees? Are they alert to recognize and reward talent?

The record of events of the recent past does not indicate that they were willing to do any of these things. Laboratories, research, and development projects were discontinued with no warning whatsoever. Technically trained men and women by the thousands were

* J. CHEM. EDUC., **14**, 260–8 (June, 1937).

told that their services were no longer needed. Invariably they were the very first to go. They were calmly kicked out with the employer's "good wishes" and absolutely nothing else. And now these employers cheerfully inform us of their desires, demand a code of ethics where they recognize none, paint a picture of their ideal chemist and vociferously cuss the teachers in educational institutions who fail to produce supermen by the thousands—for cheap exploitation.

That the training period for chemists consists of four or more difficult years seems to have no meaning to these employers of chemists, and that the expense involved is considerable is likewise carefully ignored. This expense is borne by the chemist in question, and his training represents his stock in trade. It represents no small investment in time and money, and he is entitled to a fair return. Yet these employers demand a chemist perfectly trained with the astonishing ability to leap full-fledged into their organization and start paying dividends ten minutes later. A ten-thousand-dollar man for whom they grudgingly pay one or two thousand dollars—perhaps. Truly an unusual type of mutuality, a degradation of intellectual effort.

Can anything be done about this? Can anything be done to advance the professional standing of the chemist? Undoubtedly so, but it will take time, effort, and coöperation *from the chemists themselves*. That great organization of chemists, the American Chemical Society, can exert a profound influence for good in this direction if its members are once fully aroused to the necessity for action. That the Society has become conscious of such a need is evidenced by the appointment of a committee headed by Dr. Thomas Midgeley, Jr. This committee has repeatedly appealed for suggestions and continues to do so. All chemists should respond to this appeal, for only with their help can this committee be of any value in promoting their interests.

Perhaps there are too many chemists, and the present plight of many of them is merely a manifestation of the inexorable law of supply and demand. That the unfit should be discouraged at the source, the educational institutions, is unquestionably true. Yet how is this to be accomplished? Who is to judge the fitness of a student for the chemical profession? It is not merely a matter of the mental, emotional, or physical condition at a given moment. Who can glance one single hour into the future and witness the succession of events which determines the condition of anything at the end of that period? The dull and uninterested undergraduate may be transformed into a brilliant and enthusiastic graduate. The writer has witnessed many such changes. What must we tell these ambitious boys and girls? Shall we encourage or discourage them—what of this boy who is eagerly facing me across my desk?

"So you want to be a chemist?" I asked. "Are you willing to invest at least four years of your young life acquiring hard, dry fundamentals, a discouraging task at best? Are you willing to investigate a large number of related sciences, study and learn, in order to acquire the necessary basic foundation upon which to rest your beloved chemistry? Do you know that a thorough knowledge of English is essential and that a reading knowledge of two or three foreign languages is requisite? Do you know that upon graduation you will find yourself in active, if not ruthless, competition with hundreds of others with the same ambition—to find a job? Having perchance found a job, will you be willing to accept a meager salary and to be continually haunted by the spectre of dismissal at the first dawn of lean years? In view of this, will you be willing to remain true to the ideals which actuated your youthful decision to worship at the shrine of Science? Did anyone ever tell you that she is a jealous goddess and will not share you with another but will forever demand your whole attention? And this is not all; there are other obligations. Will you be willing to work with your fellow chemists for the promotion of your profession? Do you plan to stand idly by and 'let George do it'? There is a great organization of chemists to which it will be your duty to ally yourself and faithfully serve. You can never grow bigger than this Society of chemists; you will be, at best, but an insignificant part. In view of these facts, do you still want to be a chemist? If you do, probably nothing but death can stop you—you will indeed be a chemist and a credit to the profession."

THE ROW OF INCREASING ATOMIC WEIGHTS AND THE PERIODIC LAW—A CORRECTION

Through a typographical error the entry relating to the stability of the neutron in Table 1 [J. CHEM. EDUC., 14, 436 (Sept., 1937)] was carried into the ninth column heading, which should read simply: *Half-life, T*†.

PHYTOCHEMISTRY. WHAT IT IS *and* HOW IT HAS DEVELOPED

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DEFINITION AND SCOPE

Either plant chemistry or phytochemistry would be appropriate names for the field of knowledge about to be described. However, to the industrial chemist, plant chemistry may have quite a different meaning than to the botanist. To avoid any confusion the term phytochemistry is to be preferred.

Phytochemistry is the bridge which connects chemistry and botany. By means of it, botany makes contributions to chemistry and chemistry contributes to botany. Thus, once a new compound has been isolated from plant material, the determination of its molecular structure and a study of its properties are distinctly problems of pure chemistry. On the other hand, chemistry contributes methods of isolation and of quantitative determination of plant components, by the application of which the necessary data are often secured to give sound scientific explanations of observed plant responses.

Phytochemistry is concerned primarily with two problems, (1) a study of the chemical composition of plants and (2) explanation of the various plant processes in which chemical phenomena are concerned.

The first problem includes: (a) the qualitative detection of plant components; (b) the actual isolation of plant components; and (c) the quantitative estimation of plant components without actual isolation.

THE QUALITATIVE DETECTION OF PLANT COMPONENTS

Plant material contains a vast assortment of chemical compounds, both organic and inorganic. In actively growing plant tissue, water is the most abundant chemical substance. Next in quantity are the organic compounds, and lastly the mineral. Per one hundred pounds fresh weight, the mature corn plant contains approximately 79 per cent. water; 19.8 per cent. organic compounds; and 1.2 per cent. mineral constituents. The organic and mineral components of plants may be classified as (1) commonly found present in a great variety of different kinds of plants; (2) of rarer occurrence but always present in certain definite species; and (3) chance products occurring without any regularity. Examples of the first class are glucose, fructose, sucrose, starch, cellulose, lignin, hemicelluloses, pectic substances, chlorophyll, carotenes, and xanthophylls, the common plant acids as citric, tartaric, malic, and oxalic; amino acids; various lipides, proteins, and enzymes; and compounds of such mineral elements as calcium, magnesium, iron, chlorine, sulfur, phosphorus, sodium, potassium, and manganese. In Class 2 belong glucosides; alkaloids, and many simpler plant bases; resins, terpenes, and the numerous members of the ill-defined group of essential oils; anthocyanins, phlobaphenes, tannins, suberin, cutin, gums, mucilages, higher alcohols, waxes, paraffins, inulin, chitin, and various of the rarer sugars. Silica and other non-functioning mineral compounds; as well as various injurious substances both inorganic and organic, which may enter the plant from the soil solution, are examples of Class 3.

Unless it is a question of the identification of an individual lipide, protein, or hemicellulose, the common, widely distributed chemical substances are ordinarily easier to detect than the members of Classes 2 and 3. With the latter, it is often easier to prove the absence of various substances than to definitely establish their presence in a particular sample of plant material. Fortunately, most of the thousands of different individual plant components can be assigned to certain groups or families of related compounds for which definite group tests may be devised. Thus if a plant extract yields no precipitate with the usual "alkaloidal reagents," it is quite unnecessary to test it for brucine, coniine, nicotine, and a host of other alkaloids.

It is quite apparent, though, from the great diversity and enormous number of individual chemical compounds known to occur in plant material that, even making use of group tests, no very simple scheme of qualitative analysis can be devised. Qualitative analysis of plant tissue, therefore, usually means merely a testing for the presence or absence of certain definite compounds or classes of compounds, rather than an attempted identification of all the chemical substances present in the sample. To this end many microchemical tests have been devised (*1*). These frequently are of great value in making physiological interpretations because many of them show the localization of the material for which the test is made. But all too often the effective use of such tests is limited by too small quantities of the substances present in the plant tissue to give clearly recognizable reactions; or else by the presence of interfering materials which obscure or modify the usual result.

Apart from tests for localization of materials within the plant tissues or certain very simple tests for abundant or widely distributed compounds such as starch, qualitative analysis of plant material is ordinarily carried out in connection with isolation. It thus often

takes the form of identifying substances which may be extracted by certain solvents or separated by distillation or other treatments. For example, one may attempt to identify individual lipides in the ether extract; or individual alkaloids precipitated by general alkaloidal reagents; or various terpenes or esters separated by steam distillation.

THE ISOLATION OF PLANT COMPONENTS

The desire to discover the healing virtues of plants or again, to extract deadly poisons from them, is one of the oldest endeavors of mankind. This not only represents the beginning of phytochemistry, but was also one of the original causes for the development of an independent science of botany. At first the preparation of crude infusions and extracts of various plants or plant parts was all that was attempted. Very gradually, hand in hand with the development of chemistry as a science, there grew up the desire to isolate individual compounds, *i. e.*, the active principles which were responsible for the recognized physiological actions.

Several classes of plant components were early recognized, such as gums, resins, and oils. Vinegar and even crude sugar preparations seem to have been known almost at the dawn of recorded history. Indigo was used in Egypt as early as 1500 B.C. Mummies of the Eighteenth Dynasty have been discovered with wrappings colored with this dye.

In the tenth century tannic acid was described by Abu Mansur. It was prepared from oak bark and galls and came to be one of the first widely used chemical reagents, being employed for the detection of iron.

The development of distillation methods by the Arabian alchemists contributed a valuable new procedure to supplement the crude extraction and crystallization methods of the earlier period. In the eleventh century spirit of wine is definitely mentioned as a well-known material. Certain dyes as alizarin were in common use in the form of crude extracts. But for several centuries more, progress toward the isolation of chemical compounds from plants made little headway. In fact, about the first clear-cut example of the isolation of a really pure compound, is the separation of succinic acid by the dry distillation of amber, carried out by Georg Agricola in 1546. In 1560 Alexander Pedemontanus obtained benzoic acid by a similar procedure from gum benzoin.

In the seventeenth century, thymol was recognized as a crystalline body separating from thyme oil. The latter was separated from plant material by steam distillation. A little later Angelus Sala obtained cream of tartar, cane sugar, and various oxalates by the fractional crystallization of protein-free plant extracts.

About this time the Academy of Science of Paris undertook a very comprehensive study of plant composition. But unfortunately those in charge of the investigation believed that dry distillation gave rise to the elements out of which the material was composed. Some 1400 plants and plant products were thus examined without much of importance being learned.

The decomposition by dry distillation of plant materials into gaseous products led to speculations by the earlier botanists that plants were built up of gaseous substances and it was not until the time of Boyle (1627–91) that it was recognized that strongly heating plants did not decompose them into their elements. Boyle also recognized the difference in the products obtained by burning and those obtained by heating without access of air.

But even well after the time of Boyle, many faulty conceptions of the nature of plant growth and composition still impeded progress. For example, many properties and responses of plants were ascribed to non-material causes. Also many of the known plant components were regarded as the peculiar property of a particular plant, and their wider distribution in nature went unrecognized. Thus cane sugar was described as the "essential salt" of sugar cane, potassium tartrate as the "essential salt" of the grape, and oxalic acid of sorrel (*2*).

In 1685 Nicholas Lemery first classified chemical materials according to their origins as mineral, animal, and vegetable. Vegetable or plant materials were treated in twenty-four chapters of his famous chemistry text under such headings as sugar, tartar, turpentine, camphor, opium, gum benzoin, and tobacco.

During the following century, the development of animal chemistry began to make rapid strides and in a way to eclipse phytochemistry. This was because it is much easier to observe where certain changes occur in the animal body. It is also easy to collect samples of blood and urine and to devise methods of testing hypotheses. In plants the anatomical and metabolic relationships are much more complicated and more difficult to differentiate and localize.

In the eighteenth century the earlier extraction procedure of studying plant composition returned to favor. During this period, the study of plants was still largely in the hands of pharmacists. The contributions of such men as Marggraf, to whom the beet sugar industry owes its origin; and of Scheele in Sweden, are fairly well known. By changing organic acids into their difficultly soluble calcium salts, separating these and decomposing them with sulfuric acid, the latter was successful in isolating in a pure state such important compounds as tartaric, citric, oxalic, and malic acids from plant sources. In 1784 Scheele obtained glycerin from olive oil. However, the true chemical nature of the fats was not recognized until later when Chevreul carried out his classical investigations. Scheele's investigations are of special significance to phytochemistry because of his emphasis on the actual isolation of pure chemical compounds from plants. Most of the pharmacists of Scheele's day were still content to prepare water or alcoholic extracts of plant materials; and Scheele's insistence on actual isolations gave a new angle to developments in this field. In fact, Scheele might be regarded as the founder of modern scientific plant chemistry (*3*).

The nineteenth century saw the discovery of the alkaloids, and the physiological interest of this work in

the field of medicine gave a powerful impetus to further work in plant analysis. From 1817 to 1837 no less than two dozen important members of this group were isolated. The work with the alkaloids led also to the recognition of another large group of compounds, *viz.*, the glucosides. The systematic investigation of the ethereal or essential oils was also begun in the nineteenth century, made possible by advances in the technic of distillation (fractional and vacuum). However, with the rise of modern organic chemistry, initiated by Wöhler's synthesis of urea in 1828, interest was again directed away from plant chemistry to this new field of investigation which so readily yielded results in the way of an almost unlimited number of compounds capable of being produced by laboratory synthesis. But as the novelty has worn off this kind of work, more and more investigators—many of whom had devoted the earlier part of their careers to pure organic chemistry—have returned to the still unexhausted and very fruitful field of isolations (*4*). No one knows what percentage of all the compounds that occur in plants have now been isolated and definitely identified. But certainly many thousands still are awaiting skilled investigators who will devote themselves to this task. Rochleder in his "Introduction to the Analysis of Plants and Plant Parts" (1858), laments that "the trees in whose shade we wander, as well as the plants which we meet time and again, are chemically unknown entities. We know that salicin occurs in the willow, populin in the poplar; we know amygdalin of the almond and the volatile oils of chamomile and sage, but we do not have a picture of the exact chemical composition of any of these plants. One who knows the chemical composition of valerian oil, nevertheless, knows little about the composition of the plant. Frequently one finds that more is known about the cinchona tree or other foreign plants than is known about the linden or the nut trees of our own yards."

The similarity of many plant compounds often makes separation of chemical individuals very difficult. For this reason, quite early, various group terms such as plant mucilages, resins, volatile, ethereal, or essential oils and tannins came into use. Many of these older group names have little value. For example, the essential oils are now known to be members of a wide variety of chemical families—esters, ketones, and terpenes. It is interesting to observe that when this name was given to these volatile, oily plant materials, it was believed that they were all chemically identical and that the actual odors which are always associated with them were due to contamination with specific gaseous "odor principles" which were characteristic of the plants from which they were obtained. In fact, many problems dealing with the identity or difference of various plant components have been very difficult to solve. Thus, the question of whether or not chlorophyll from different species of plants has the same composition was only decided by the comparatively recent work of Willstätter and his associates (*5*). This resulted in the recognition of chlorophyll *a* and *b* as the common chemical components of the chlorophyll of all plants.

Near the middle of the nineteenth century, Ritthausen began his extensive investigations of vegetable proteins, which led ultimately to the isolation of various amino acids from plant products. Many fatty materials were found. A great assortment of carbohydrates were added to the list of known plant components.

In the most recent years, the extraction of enzymes, vitamins, and growth substances from plant materials has received much attention. Many new glucosides have been described. Since the chemical nature of vitamin A shows that it is closely related to one of the carotenes, the carotenoids have been the objects of many investigations. Plant components of insecticidal value are being diligently sought (*6*). Several new anthocyanins, amino acids, glutathione, and even paraffins have been identified in various plant materials.

As previously mentioned, the object of isolation may be to obtain samples of certain compounds for perfectly definite or possible uses. Thus the early pharmacists who started phytochemical investigations were interested in obtaining materials which would be of value in medicine. More recently another object of isolation has been for the purpose of obtaining information about the composition of plants which may be applied in the explanation of physiological processes occurring in them. Thus, if in explaining some plant synthesis one assumes that certain compounds are intermediates in the process, the actual isolation of these compounds lends support to the hypothesis.

Especially in the interpretation of processes where it is imperative to know exactly what compounds are reacting, the question often arises whether the compound isolated really occurs as such in the plant. We do know that often even very mild treatments will affect the composition of certain substances known to occur in plants. Alcohol often deleteriously affects enzymes; and it causes a definite change in the composition of chlorophyll. Gentle heating (65°C.) may irreversibly coagulate proteins. Not only do the reagents themselves sometimes change the composition of the material which one desires to extract, but exposure to air during drying or during the extraction of the plant material may cause changes, especially in the composition of unsaturated components. By use of modern refined technic as vacuum drying and vacuum distillation, many but not all, of these unwished-for changes may be avoided.

THE QUANTITATIVE ESTIMATION OF PLANT COMPONENTS

This phase of the study of plant composition is often carried out in connection with problems which belong to the second main division of phytochemical investigation, *viz.*, the interpretation of certain plant processes. However, it may be merely for the estimation of how much of some useful compound is present in a sample of plant material, and hence how valuable that material is as a source of this compound. Thus the quantity of a certain alkaloid may be determined in a plant bark; or the quantity of pyrethrum in pyrethrum flower heads. The former type of problem is the more fundamental to

the development of phytochemistry. It is indeed surprising how little is yet known about the mechanism of such outstanding processes in plants as photosynthesis, fat synthesis and degradation, protein metabolism, and the compounds directly concerned in plant respiration. But perhaps this is to be expected when one considers how limited is our knowledge of the simpler problem of plant composition.

The question might be raised why the quantitative analysis of plant tissue should be designated as an important division of phytochemistry. Is not all quantitative analysis alike? Is not a sugar determination merely a sugar determination, no matter what the material is that is being analyzed? The answer is that the quantitative analysis of most plant materials calls for special methods because of the complicated composition of most plant tissues in which reducing substances other than sugars, numerous pigments which are difficult to remove, and colloidal systems often make analysis much more difficult than that of a simple water solution. Even the methods of animal chemistry usually cannot be carried over into plant chemistry without modification. These facts are too often overlooked by investigators untrained in phytochemistry, and not a few papers have crept into the literature in which the author, using an ordinary approved method for an uncomplicated water extract, or a method devised for determining the material in animal tissue, thought that he was actually determining the substance in question, but really was determining something else in the plant tissue that gave similar reactions; or at least was obtaining quite erroneous results.

THE EXPLANATION OF CERTAIN PLANT PROCESSES

Investigations dealing with the chemical interpretation of certain plant processes were begun at a much later date than experimentation dealing with the isolation of plant components. This was due partly to the dominance of alchemy during the beginnings of chemistry as a science, in which the guiding principle was the search for a material; and partly because of more practical reasons, namely, that from earliest historical times it has been known that certain plants yield medicines and poisons; hence the search for new and more efficient ones was a natural and logical development.

For centuries the views of Aristotle concerning the nature of plants prevailed with only slight modifications. The root was believed to be of importance as an anchor and in taking up already elaborated nutrient materials from the soil; and the significance of the seeds but not of the leaves was recognized. Many analogies were drawn between plant and animal behavior. The roots were thought to correspond to the mouth of an animal. Trees which shed their leaves in autumn were compared to birds during the moulting period. Leaves were, therefore, the analogs of hair or feathers in the animal world. The discovery during the seventeenth century of the circulation of blood in the animal, led to a search for a similar process in plants.

Although Leonardo di Vinci (1452–1519) probably had similar ideas somewhat earlier, Malpighi seems to have been the first (1686) to have satisfactorily demonstrated that leaves are of importance in changing food materials taken up by the roots.

Bernard Palissy (1510–89) writes of restoring to the soil salt removed by crops and even went on to claim that manures returned to the soil something that had previously been removed by plant growth. Palissy's ideas were simply based on quite general observations. The first definite connection of a mineral salt with plant metabolism came from investigations carried out by Glauber in 1650. The latter instituted a search for substances in manures which favorably influenced plant growth on manured soils. He was successful in isolating potassium nitrate and in proving that application of this salt to a soil would greatly increase plant growth.

Van Helmont's famous experiment (1648) with a willow tree did not lead to such fortunate and correct conclusions about the source of materials for plant growth. A willow twig was grown in a tub of soil which was watered daily with rain water. When the tree had gained in weight almost thirty-four fold, the soil was dried and reweighed. Due to difficulties inherent in drying the soil to its original condition and weighing so large a sample accurately erroneous results were obtained. The soil apparently had lost nothing. From these results Van Helmont concluded that water must be the sole source of material for plant growth.

In 1699 John Woodward conducted some experiments upon the influence of water from various sources upon plant growth. Using rain water, water from the Thames River, and sewage water, he was able to demonstrate marked differences in the growth of his plants. He also observed that water taken up by the plant passes as vapor into the atmosphere. Woodward concluded that "a great part of the terrestrial matter, mixed with water, passes up into the plant along with it, and the plant is more or less augmented in proportion as the water contains a greater or less quantity of that matter." Stephen Hales (1677–1761) on the other hand, insisted in his "Vegetable Staticks" published in 1731, that air is the important material "wrought into the composition" of plants.

Although many of the above observations were at least partially correct and were the forerunners of much greater discoveries to be made later, very little was really understood about the nature of any plant process until after Priestley's discovery of oxygen in 1774 and Lavoisier's interpretation of the rôle that it plays in oxidation and respiration (7). In fact, not until the time of Black (1757) was it recognized that the gases produced by burning, respiration, and fermentation are composed largely of one and the same chemical compound, carbon dioxide. Lavoisier's explanation of the processes of burning and of respiration formed a

new foundation upon which all the succeeding work in phytochemistry could securely rest.

To Jan Ingenhousz (1730–99), therefore, really belongs the credit of being the first investigator in the field of plant chemistry whose experiments and deductions concerning chemical processes in plants were based on sound chemical theory (*8*). Many of Ingenhousz's conclusions can be carried over quite unchanged to form a part of our present-day phytochemistry. It was Ingenhousz who demonstrated clearly that light and green leaf pigments are necessary for the liberation of oxygen by plants. Although Priestely had previously found that oxygen is liberated by plants under certain conditions, he was unable to secure consistent results because he could not determine just what these conditions might be. Notably he did not observe the connection of light with the process, which Ingenhousz did.

In 1732 Senebier showed that carbon dioxide contributes to the increase in weight of a green plant growing in sunlight and that it is also a probable source of the oxygen that is given off when the plant is exposed to light.

At the beginning of the next century, Th. de Saussure's work, "Recherches chemiques sur la vegetation" (1804) stands preeminent. De Saussure was the first to introduce quantitative methods into plant experimentation. He was also the first to define plant respiration and to show that it differed from photosynthesis. It was de Saussure, too, who proved that plants utilize hydrogen and oxygen from water for food manufacture; and that the free nitrogen of the air is unavailable to most plants; while nitrogen compounds, as nitrates, are utilized. At the time, little notice was taken of these discoveries and in spite of de Saussure's suggestions, the idea of pre-formed plant food in the soil as exemplified by the "humus theory" prevailed for many years more.

In examining the history of the relation of minerals to plant growth, one finds that although there are isolated instances in older writings of the recognition of the value of gypsum and limestone in agriculture, there seems to have been no attempt to correlate their effect with the composition of the crop plants. To be sure, the presence of alkaline materials in plant ash was known in very early times. Aristotle describes the production of lye from wood ashes. Much later, in the sixteenth and seventeenth centuries, the observations, already mentioned, of Palissy, Glauber, and of Woodward, stand out as isolated beacons. But until well into the eighteenth century, it was not generally known whether alkalies preexisted in the plant or were produced by the burning. In this connection it must be remembered that until the time of Lavoisier, many chemists believed that any residue remaining from the distillation of water was due to a decomposition of the water; and furthermore that Van Helmont and others had claimed to have adduced indisputable proof that when plants increased in weight, water was the only material required. Even as late as 1800 a prize was conferred by the Berlin Academy for a thesis which was believed to prove that mineral substances in plants were produced by the vital activity of the plant.

A little later, Boussingault in France and Sprengel in Germany, applying the quantitative experimentation developed by de Saussure, carried out investigations dealing with crop rotations and ash constituents of plant materials some of the main results of which, incorporated into Liebig's "Chemistry in Its Applications to Agriculture and Physiology" (1840), gained wide circulation. Gradually, as the result of ash analyses, the relation between the minerals present in the soil and those in the plant came to be clearly recognized. The experiments of Wiegmann and Polstorff (1842) in which they grew seedlings in sand that had been strongly heated and found that the mineral matter in the seedlings was no more than that already present in the seeds, opened a new epoch in agricultural experimentation. Shortly after this, the Count of Salm-Horstmar introduced deficiency experiments (1849–56) in which plants grown in sand cultures free from soluble minerals were supplied with various solutions containing known concentrations of different mineral elements. This method was developed further by Hellriegel, Sachs, and Knop and still is a common type of experimentation in phytochemistry. The importance of certain elements for plant growth was soon established. Largely as the result of the teachings of Liebig, Davy, Dumas, and Berthelot, the practical significance for agriculture of discoveries in plant chemistry and physiology came to be recognized, and considerable attention was given to the establishment of agricultural experiment stations. Thus, in bringing these discoveries of the relation of minerals to plant growth into actual agricultural practice, the work of Lawes (1814–1900) and Gilbert (1817–1901) at the Rothamstead Experiment Station in England is of particular importance.

In spite of all the work which has been done in recent years on the mineral metabolism of plants, this field is far from exhausted. The exact physiological functions of many of the elements recognized as essential are still unknown. Also much remains to be learned about many mineral elements which often occur in plants and in the soil in very small quantities such as copper, boron, and zinc. For certain plants, at least, these must also be numbered as elements essential for growth.

As long as the existence of bacteria and a knowledge of the changes wrought by microörganisms in the soil were unknown, a satisfactory interpretation of the probable source and rôle of nitrogen in plant growth presented many difficulties. It was finally recognized that the air contains a large amount of free nitrogen and that ammonia may result from the decay of certain organic materials in the soil. As a consequence of some faulty experimentation, it was believed for many years that higher plants utilized free atmospheric nitrogen. De Saussure (1804), however, disproved this and called attention to the ammonia in the air as a possible source of nitrogen for plant growth. Here again, incorrect measurements, showing relatively large quantities of

ammonia present in air, led to the development of erroneous hypotheses. The idea was also advanced (Mulder, 1842) that humus in the soil serves as the material for protein synthesis in plants. This view, backed by many prominent chemists, gained considerable headway. Not until bacteria were recognized as playing important rôles in natural cycles was the importance of nitrates and of ammonium salts of the soil solution recognized and the true source of nitrogen for plant growth discovered. Along with this, the capacity of certain bacteria and lower forms of plant life to utilize atmospheric nitrogen (Hellriegel and Willfarth, 1886) was also established (*9*).

Even as late as Liebig, plant respiration was vigorously denied, although the production of carbon dioxide by green plants in the dark had been definitely established. Gradually the distinction between photosynthesis and respiration came to be recognized. At the same time the belief was discarded that there existed a delicate balance in nature in which plants built up food materials which animals then decomposed in such a way that the products of decomposition were used again by the plants and that these processes formed a continuous cycle. Largely as the result of the careful work of J. Sachs (1832–97), (*10*), it became evident that plants not only synthesized foodstuffs, but also utilized some of these same food materials to carry on the process of respiration which was essential to their photosynthetic activity. It was Sachs also who first recognized starch as a product of photosynthetic activity in the green leaf.

Along with the rise of bacteriology, a study of the mechanism of fermentation led to the discovery of those most important organic catalysts, the enzymes. Although Spallanzani (1785) showed that gastric juice could dissolve protein, little notice was taken of his observation. In phytochemistry the earliest mention of a similar phenomenon seems to have been made by Kirchhoff, Irvine, and Dubrunfaut who observed the enzymatic decomposition of starch; and in 1833 Payen and Persoz studied the action of malt diastase quite thoroughly. However, until Büchner's experiments in 1897 it was believed that there existed two kinds of biocatalysts: organized ferments which were active only in the presence of living cells; and unorganized ferments (called enzymes by Kuhn in 1867) which were active when secreted or when separated from living cells. Büchner proved that zymase, the organized ferment causing alcoholic fermentation, could act in the absence of yeast cells and subsequent experimentation confirmed his view that there is no fundamental difference between organized and unorganized ferments. Both kinds of ferments then came to be known as enzymes. The importance of enzymes in both plant and animal processes is one of the outstanding characteristics of living matter. Living organisms seem to be largely expressions of coordinated enzyme activities. We even now only remotely glimpse the far-reaching effects of these still very meagerly known chemical substances. Some—perhaps all of them—are proteins. But there our knowledge ends.

The course of photosynthesis in the green leaf still presents a major problem in phytochemistry. Although many of its larger aspects—the importance of sunlight, chlorophyll, carbon dioxide, and water, and the rapid appearance of starch and sugars—are well known, the exact mechanism of chlorophyll action as well as the intermediates formed in the progressive building up of the starch from the very simple raw materials, carbon dioxide and water, are still mysteries (*11*). To Willstätter and his associates we owe much of our knowledge of the chemical composition of chlorophyll, but one cannot yet write a complete structural formula showing the exact chemical constitution of either of the closely related modifications, *a* and *b*, which make up natural chlorophyll.

No history of plant chemistry is complete without special mention of the work of E. Schulze (*12*). A lifetime of effort in this field in which he continued to work even when threatened blindness had seriously hampered his activities, resulted in the publication of scores of papers, many of which are of outstanding merit. Schulze was to a certain extent an isolator, and his name is linked with the discovery of several amino acids and plant bases. But he was also an investigator of plant processes and contributed much to an understanding of the nitrogen metabolism of plants and how it is related to carbohydrate metabolism.

As one approaches the more recent developments in the study of plant processes, perhaps the germ of the outstanding idea which has given direction to a great volume of recent work in phytochemistry as well as in plant physiology, may be found in some work of Klebs (*13*). Klebs believed that every species has a sum total of potentialities constituting the specific nature of that species, but that the chemical and physical conditions prevailing at any time within the organism determine which of the particular forms that the species is capable of producing shall appear; and that these inner conditions may be controlled to an extent, at least, by regulating the external conditions. Thus by merely altering the composition of the solutions in which he grew *Saprolegnia*, Klebs was able to bring about vegetative growth alone, asexual spore formation, or to induce the sexual phase of development. Recent studies of chemical and physical correlations such as the C/N and other ratios, and the effects of light and of temperature on plant composition and responses, go back fundamentally to the ideas of Klebs.

A phase of investigation in phytochemistry, which at present has captured a leading rôle, deals with the study of the chemical nature and effects of various stimulants and growth substances in plants. The latter are sometimes, with doubtful accuracy if one accepts their usual definition in animal chemistry, designated the plant hormones (*14*). Examples are the auxins which affect cell elongation and root formation as well as various chemicals of quite unrelated composition such as naphthalene acetic acid and indole butyric acid which exert

similar effects. Other chemicals as ethylene chlorhydrin (*15*) have been found to be useful in breaking dormancy.

CONCLUSION

In a perusal of the historical development of phytochemistry, it is quite evident that many of the investigators, especially those who contributed to the earlier development of the science, laid no claim to being plant chemists. They were physicians, pharmacists, and later botanists and chemists. But, of course, the same thing is true in the development of any other science. The founders of chemistry were the alchemists and physicians, and men of very general philosophical interests. The founders of bacteriology were chemists and medical men.

The same overlapping with related sciences is also to be noted here as with every other science. As chemistry grades through physical chemistry into pure physics, so does phytochemistry, as mentioned at the beginning of this article, grade on one hand into botany, particularly plant physiology; and on the other hand into pure chemistry. There is certainly no hard and fast line of demarkation to show where plant physiology leaves off and phytochemistry begins. It is usually much easier to differentiate between phytochemists and plant physiologists. The former have ordinarily devoted a much larger proportion of their fundamental training to various aspects of chemistry; coupled with a lesser degree of training in the various specialized fields of botany. In general, just the reverse is true of the training of the plant physiologist. This gives rise to slightly different viewpoints. Frequently the man with the considerable training in chemistry is prone to lean very noticeably toward simple, logical hypotheses explaining plant processes. Unfortunately it seems that plants are not always given to following such logical procedures. In the words of Pfeffer, it is a very confusing error to presume that an organism must, in its metabolic economy, follow a course which to man, under the influence of existing chemical and physical conditions of knowledge, seems to be the most plausible course. The formaldehyde hypothesis in photosynthesis, might be cited as an example. Through its logical appeal it has dominated most discussions of the mechanism of the utilization of carbon dioxide by plants, although in over fifty years, very little evidence has been adduced in its favor. Its wide-spread acceptance, perhaps, has impeded more fruitful lines of attack.

On the other hand, men whose training is largely in botany, sometimes err in assuming that chemistry is a magical touchstone which will quickly explain everything, without realizing some of the present-day limitations of our chemical knowledge and ofttimes how difficult or even impossible it is to obtain the necessary chemical data upon which sound deductions might be based. Even an "Official Method" will not always serve to determine a certain plant component in every kind of sample of plant material; and mistakes of misplaced confidence are easily made by the uninitiated.

The marked development in plant experimentation of a chemical nature during recent years is well shown by the number of papers of this kind abstracted by *Chemical Abstracts*. Segregation of such papers in a special division "*Botany*" under "*Biological Chemistry*" was started in 1912. In that year one hundred eighty-three such abstracts appeared. In 1936 the number had increased to eight hundred forty-nine.

SOME PRESENT-DAY PROBLEMS IN PHYTOCHEMISTRY

One might summarize some of the outstanding present-day problems in phytochemistry as follows:

1. What is the mechanism of the action of chlorophyll in photosynthesis? What intermediate substances are produced?
2. How are proteins synthesized in the plant? Exactly what happens to the simple nitrogen-containing compounds of the soil solution? What forms of carbohydrates are used in the process? Why is the number of different amino acids formed in plants comparatively limited?
3. What is the origin of fats in plants? Particularly what intermediates are concerned in carbohydrate $\rightleftarrows$ fat metabolism?
4. What are the functions of such minerals as potassium, phosphorus, sulfur, manganese, and iron in plant processes? What minerals are always essential in extremely small quantities for plant growth? Are these required by all higher plants? Do different species of plants require quite different concentrations of essential elements for optimum growth and what are the compositions of such solutions?
5. What is the nature of plant respiration? What substances are actually oxidized? What are the intermediates and catalysts concerned?
6. What are all the different compounds present in any particular plant? Do methods of isolation often yield different materials from the ones actually present in the plant?
7. What are the external conditions which favor an increase in the quantities of certain valuable plant components such as carotene, various alkaloids, or insecticidal principles?
8. What effects have various external conditions, as fertilizers applied to the soil, on the quality and spoilage in storage of fruits and vegetables?
9. What are the functions, if any, of such plant components as glucosides, tannins, and carotenoids?
10. What is the origin of vitamins in plants? How may the vitamin or pro-vitamin content be increased?
11. What are the chemical natures of various stimulants, growth substances, or "plant hormones" and how do they affect plant metabolism? Are there chemical substances which will induce flowering as well as root formation?
12. Just exactly what internal ratios are related to vegetative growth, flowering, and fruiting? To what extent are they qualitative and to what extent quantitative?

13. What is the relation of external conditions to the quantity and the quality of oil in a fatty seed?

14. What are the chemical aspects of immunity in certain strains of crop plants?

15. Better methods of isolation and of qualitative and quantitative analysis are also needed for the identification and determination of many plant components.

These are merely a sample of some of the more important problems awaiting solution in phytochemistry. There are many others. Each stands as a challenge to the imagination and ingenuity and laboratory skills of everyone interested in chemistry or in plants.

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BIOCHEMISTRY OFFERED IN COLLEGES OTHER THAN UNIVERSITIES AND MEDICAL SCHOOLS

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FOR some years now at City College we have been offering two courses in biochemistry; the one is a term's work of an introductory kind; the second is of a more advanced nature and wholly quantitative, dealing largely—in the laboratory, at least—with blood and urine analysis. The two courses are elective; open to students who have had general, qualitative and organic chemistry (for the introductory course) and quantitative analysis (for the advanced course).

Biochemistry as offered in our college has at no time been regarded as a premedical requirement. The subject has been viewed more in the light of Wieland's definition of it, as "the most important branch of organic chemistry." In this sense the subject assumes interest for any science student, irrespective of subsequent specialization.

I have been interested in determining to what extent biochemistry is being offered in the various *undergraduate* colleges of the country. With this in view, I wrote to the secretaries of undergraduate "colleges with $2,000,000 endowment or over"—some fifty-one institutions. To date, forty-three have replied. Of this number, twenty-three offer courses in biochemistry. They are Barnard, Beloit, Berea, Bowdoin, Brooklyn (New York), Bryn Mawr, City (New York), Cornell (Iowa), George Peabody, Goucher, Hunter (New York City), Knox, Lindenwood, Macdonald (Canada), Mt. Holyoke, Mt. St. Joseph, Oberlin, Rutgers (College Department), Simmons, Trinity, Tuskegee Institute, Webster, and Wellesley. Eight of these institutions not only offer courses in biochemistry but courses in food chemistry: Berea, George Peabody, Lindenwood, Mt. Holyoke, Simmons, Tuskegee Institute, Webster, and Wellesley. Finally, three offer a course in food chemistry only: Colorado, Hampton Institute, and Vassar.

Biochemistry, obviously, is making headway in undergraduate colleges.

SCIENTIFIC *and* TECHNICAL ACHIEVEMENTS

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INTRODUCTION

PROGRESS in scientific and technical fields may be considered slow or rapid, according to the standpoint of the observer. If one admires the wonderful artistic and technical objects which were made more than five thousand years ago in Babylon, Egypt, China, and in India, one may say that progress in the technical field is not very rapid. When one considers special technical developments in certain fields in the last fifty or hundred years, one is puzzled by the speed of progress which is made every day. Very often, in former days, technical progress met with resistance. When the first railroad was built in Germany, a little more than one hundred years ago, the University Faculty of Erlangen gave an expert opinion that the persons in a train which would move with a speed of about twelve miles per hour would be killed by the high pressure produced, and that the same would happen to those persons who would stand on the sides of the rails where the train with this speed came along. Another example of prejudice against technical progress is the interesting story of Samuel Clegg. It is known that more than one hundred years ago Clegg introduced illumination with gas in London. His opponents stated that the storage of illuminating gas would be extremely dangerous, because it would explode of itself. Clegg invited his opponents into the building in which he had established a gasometer. With a pick he made a hole in the gasometer, which was under elevated pressure, ignited the gas, and no explosion took place.

Much progress is continuously made by the innumerable unknown soldiers of science and technic. From this mass famous scientists and technical men project like islands from the sea or the peaks of mountains from the mist.

ROMANTIC AND CLASSICAL TYPES

Wilhelm Ostwald told us that many years ago the Government of Japan asked him how one could recognize men of genius in their youth. It is of really great importance to know something about the disposition and the character of those great men to whom we owe so much gratitude for their performances in so many different fields. According to Ostwald, most of the great men belong to two classes. Those who in their youth—say between twenty and thirty-five years—perform great work, belong to the romantic type. The classical type represents those men who perform during a long life several or many great achievements. Representatives of the first-mentioned romantic type in the fields of art and music are Raphael, Mozart, and Schubert; in the field of chemistry, Liebig, Gerhardt, Alfred Werner; in physics, Einstein, Hertz, and many others. Representatives of the classical type are Leonardo da Vinci, Michelangelo, Spinosa, Kant, Beethoven, Helmholtz, Pasteur, Darwin, Wöhler, Bunsen, Gibbs, and others.

Alfred Werner developed, when he was twenty-five years old, the coördination theory which he published in 1892. He predicted at this time the possibility of splitting inorganic substances in optical antipodes. Twenty years later he carried out this extremely important work. All of his fundamental research work which he did afterward during his scientific life was based on this one great first publication. The fundamentals of chemotherapy, a science which was founded by P. Ehrlich, are developed in his dissertation. On the other side, men of the classical type, like Newton or Faraday, perform during a long life many deeds of the greatest value.*

Several points may be mentioned which seem to be necessary for the development of new important and unexpected achievements. Influences outside and inside the personality of those great men enable them to do their work. Outside the personality, but playing a great rôle, are lucky accidents.

LUCKY ACCIDENTS

The invention of the vulcanization of rubber, a very far-reaching invention, was made nearly a century ago by a happy accident by S. Goodyear. The invention of the latent image with the help of mercury vapor was made accidentally.

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* See Faraday's life.

24 years old:	Assistant Royal Institution, benzene discovered
30	First work on electro-magnetism
32	Liquefication of chlorine
40–49	Researches on electricity, 23 series of publications
50	Grave illness, partial loss of memory (poisoned with mercury)
53	Relationship between magnetism and light
60	Magnetic lines of force
61	General gravitation
64	Last series on electricity
65	Colloidal gold
66	Temporal qualities of distance actions
71	Influence of magnetism on spectral lines
76	Death

The founder of the modern rayon industry was the French Count Chardonnet. It is known that he used a solution of nitro cotton in ether-alcohol, and that he pressed this viscous solution through capillaries into water which served to coagulate the cellulose nitrate filament. After the coagulation, this filament entered the air and was wound up on bobbins. One day Chardonnet inspected his French factory at Besançon. By an accident the water which should coagulate the cellulose nitrate filament was stopped. The workmen found that the spinning operation went much better without water than with water. This was the birthday of the very important process of dry spinning, which is actually carried out on the greatest scale.

Mittasch, the great specialist in the field of catalysis, investigated iron ores on the advice of Bosch. These iron ores had to be reduced with hydrogen at low temperatures to get an active iron catalyst for the ammonia catalysis. With different iron ores Mittasch found completely different results. One Swedish iron ore gave excellent results. This iron ore was carefully analyzed. Aluminum oxide was found. It could be shown that the aluminum oxide played a very important rôle in the catalytic process, in spite of the fact that it was not a catalyst for the nitrogen-hydrogen catalysis itself. In this way the so-called "mixed catalysts" were invented—or better—re-invented, because afterward it could be shown that men like Doebereiner and Wöhler knew a lot about those mixed catalysts. But their doctrines were completely forgotten.

Another case may be mentioned in this connection. In one of the plants of the German I. G. a steel bottle with compressed carbon monoxide was kept for rather a long time. It was observed that a liquid was formed. The bottle was emptied, the liquid was investigated, and iron pentacarbonyl, known since Mond and Langer, was found. Chemists could not find any use for this material for a long time. When in this country lead tetraethyl was introduced as a very powerful anti-knock material, by Thomas Midgley, Jr., experiments were carried out in the I. G. to replace the extremely poisonous organic lead compound by other material. By an accident, a chemist used this formerly useless iron pentacarbonyl as anti-knock material and found that it gave very interesting and important results, not as good, however, as one could obtain with the poisonous lead tetraethyl.

A striking example of luck is the invention of Thiokol, a very important substitute for rubber. Dr. Patrick wanted to produce ethylene glycol. To do this he treated ethylene dichloride, not with a cheap base like lime, but with the more expensive and disagreeable sodium tetrasulfide. He observed a rubber-like material. An important discovery was made by a very happy accident.

A similar very important case happened when Sapper tried to oxidize naphthalene with sulfuric acid to get phthalic acid. The yield was very small. In one experiment the thermometer broke, and mercury was mixed with the naphthalene-sulfuric acid mixture. A very high yield resulted. This oxidation process, found by accident, was used during many years till the catalytic oxidation of napthhalene with air, invented by A. Wohl, was introduced.

The inventor of steel making, Henry Bessemer, observed when he tried to make malleable material from cast iron that he could do this with hot air without changing the solid state of the material. This simple observation was afterward of the greatest importance. He asked himself if he could not burn the carbon from pig iron by introducing cold air into molten pig iron, and at the same time get molten steel. Experiments on a small scale showed him that the heat which was evolved by the combustion of silicon and carbon could maintain the molten mass in this state. In his extremely interesting autobiography he describes his work, and the reader follows a real sensational romance in reading Bessemer's description. Without the first insignificant observation, Bessemer probably would not have conceived the important idea of introducing cold air into a molten metal mass. Before he did so, experts told him that his idea was foolish, and that after a short time this molten mass would be transformed into solid material. Bessemer had good luck in using for his first fundamental experiment phosphorus-free Swedish pig iron. With phosphorus-containing English pig iron he and his friends afterward had enormous difficulties. Twenty-four years were needed till Thomas and Gilchrist found that bases bind the phosphoric acid produced and prevent the reintroduction of phosphorus into steel. It is known that Bessemer, by his invention, made a great fortune; that he lowered the price of steel from 50 or 60 £ a ton to 6 or 7 £ a ton; and that he and his friends got for each £ which they put in the business a return of 80 £ after fourteen years.

Very often great discoveries and inventions are made without a thought of making money with them. Faraday refused to do industrial work, even when to do so would have brought him large sums, and he preferred to be a scientist with a rather modest income. The writer remembers very well that Alfred Werner seemed to be offended when an industrialist asked him to do some technical work for him. Peter Griess, the inventor of the diazonium compounds, which are the basis of many very important dyestuffs, had no financial result of his fundamental discovery.

It is known that the great Austrian chemist, Auer von Welsbach, discovered in heating a small amount of thorium oxide the very important property of this compound to send out light if heated. He found very soon that a mixture of 99 per cent. thorium oxide and 1 per cent. of cerium oxide gave the best results. We know that his incandescent light played a very great rôle during a rather long period. The same inventor, who was a great genius, found by an accident, the very interesting property of the cerium-iron alloys to form sparks. Auer tried to do something with the large amount of cerium compound residue which he got from the monazite sand after the extraction of the thorium

content. He electrolyzed the cerium compounds with an iron cathode. Cerium was deposited on the iron wire. Auer tried to remove the cerium from the iron wire with a knife. He found that sparks were formed, due to the very low ignition temperature and high ignition heat of cerium. He tried to get patents, knowing that this was a very important discovery. He got patents, but those patents were destroyed because it was found afterward that Bunsen had discovered the same effect, but Bunsen's invention was made long before the time was ripe, and then was forgotten.

TIME-BOUND INVENTIONS AND DISCOVERIES

A very important factor is therefore that the achievements are useful for the time being. We know that rather often men have wonderful ideas, but the time is not ripe, and hence very often the names of those men and their achievements are forgotten, or the merits are recognized long after their death. A countryman of the writer was the great biologist, Mendel. He was an abbot. He found extremely important results on heredity. Probably no one scientist knew, during Mendel's life, about his work because it was published, like the work of Couper and Loschmidt, the contemporaries of Kekulé, in periodicals which were not read. Many years after Mendel's death, his experiments and conclusions were brought to light, and a new science was based on this wonderful, but forgotten, work.

Bunsen laid the fundamentals of electrochemistry. He had no success, because his inventions were far ahead of his time. Many years had to elapse, till the dynamo was invented. It made possible the production of cheap electrical power. Therefore, Ramsay's word is right, "What today may be a remarkable scientific thing is tomorrow a cheap article of commerce."

Much progress has its roots in ideas which were expressed many years before. We know from experience that concerning inventions, one always can find in the patent records many proofs that other brains have thought over the same problem and have found solutions which were nearly as perfect as the final invention.

VISION

What is especially characteristic of great investigators in scientific and industrial fields is vision. Very often fundamental revolutionary ideas seem to be evolved spontaneously, just as Minerva sprang from the head of Zeus. This is really not the case. There is no doubt that in the sub-consciousness such ideas are formed, but that they, like a vision, come to light spontaneously. In this connection it may be remembered that Kekulé, through dreaming, came upon his most important work: first, the so-called structural chemistry which includes the conception of the four-valent carbon and the capacity of carbon to combine with itself; and second, the benzene theory. When after twenty-five years of its existence the anniversary of the benzene theory was celebrated, Kekulé told how he found these very important progresses. Kekulé's own words may be quoted.

"I was riding home (during his stay in London), as usual sitting outside on the roof of the bus. The streets —so crowded in the daytime—were deserted at this late hour. And I was lost in dreams! Before my eyes the atoms were dancing. I always had seen them in motion, these little elves, but I never succeeded in finding out the way of their movements. This day I saw that two smaller ones joined together, forming a couple. Larger ones embraced two little ones, and still greater ones held fast even three and four of the small ones; and altogether turned around in whirling rings. I saw that the larger ones, forming a chain, dragged along the little ones on the ends of the chain. The conductor's call awoke me out of my dream, but I spent a part of the night writing down sketches of these dreams."

Kekulé thus describes the way in which the benzene theory came to his mind.

"During my stay in Ghent, Belgium, I was sitting and writing my book on organic chemistry, but could not get along very well, as my mind kept wandering to other things. I turned the chair toward the fire place and was overcome by a sort of disturbed sleep. Again the atoms danced before my eyes. Smaller groups remained modestly in the background. My spiritual eye, sharpened by always repeating dreams of a similar kind, now distinguished larger structures of various forms. Long chains, compactly joined together, all in motion, wound and twisted like snakes. All of a sudden, one of the snakes seized its own tail, and, sneering, this structure danced around in a whirl before my eyes. I awoke as if struck by lightning. This time I again spent the rest of the night working out the consequences of this theory."

In the same way Werner found his most important coördination theory—by dreaming. He was a young assistant professor and was occupied with the preparation of his lectures concerning the theory of inorganic compounds. One night he dreamed the principal points of the coördination theory which bears his name. He awoke, left his bed, and worked several days and nights to write down his famous previously mentioned publication of the theory of inorganic compounds.

Another example of the importance of vision is the invention of the exclusively used contact material—alpha iron—in the hydrogenation of nitrogen. Haber suggested osmium and afterward uranium as catalysts. Soon, it could be seen that the available quantities of these materials were extremely small, so that a big industry could not be based on these contact materials. Bosch suggested to Mittasch the use of iron as contact material with the argument that *iron has a complicated spectrum*. Bosch did not know that long before his time iron had been used as a catalyzer. Research work carried out afterward on a very large scale has shown that only alpha-iron plus alumina and potassium hydroxide acts as a powerful catalyst and that all ef-

forts to replace it by other materials which would act at lower temperatures have failed till now.

The great discovery of Laue was made during a talk with Ewald. The writer is in the very happy position of being able to reproduce Professor Laue's own words which he got from this great scientist.

"As early as Hauy and Bravais, mineralogists had illustrated the crystallographic fundamental law of rational indices simply and clearly by the space lattice arrangement of the atoms. Sohnke and Fedorow and Schönflies had brought the mathematical theory of all possible space lattices to utmost perfection. In Munich, P. Groth impressed me the more profoundly, since, as against all doubts which some philosophers (though there were but few left in my time) had about the reality of atoms, I had made up my mind early that there were no convincing logical reasons against it, while experience again and again furnished new corroborations for it.

"This was the state of affairs when some evening in February 1912 P. P. Ewald came to me. At Sommerfeld's instigation he was engaged in the mathematical research how electromagnetic long waves behave in a space lattice. During that conversation the proximate idea occurred to me to inquire into the behavior of waves which are short compared with the lattice constants of the space lattice. Here my optic instinct said at once: There must be lattice spectra in this case. The fact that the lattice constants of crystals is 10^{-8} cm. was sufficiently known from the analogy with other distances of atoms in solid and liquid substances and, furthermore, was easily substantiated from the density, the molecular weight, and the mass (which just then had been determined very accurately) of the hydrogen molecule. The magnitude of the wavelength of X-rays, as estimated by Wien and Sommerfeld, was 10^{-9} cm. Consequently the relation of wavelength and lattice constant was extremely favorable if X-rays were transmitted through a crystal. I said at once to Ewald that I expected interference phenomena in X-rays during this transmission. W. Friedrich, too, was soon told so. While he declared himself ready at once to make an appropriate experiment, the idea at first was somewhat doubted by the recognized authorities in our science, to whom I soon had the opportunity to present it. It required a little diplomacy to get permission for Friedrich and Knipping to make the experiment in accordance with my scheme with means which at first were to be quite simple. Cupric sulfate was used as crystal, because it is easy to get large and regular pieces of it. The direction of radiation we left to chance.

"Even at the first experiment the photographic plate behind the crystal showed a great number of deflected rays: the expected lattice spectra."

Berzelius and his eminent enemy-friend, Liebig, have shown the importance of vision. Based on a few facts—the ignition of oxyhydrogen gas with platinum found by Doebereiner; the decomposition of hydrogen peroxide with metals and metal oxides found by Thénard; the dehydration of alcohol with platinum by H. Davy; and the production of large amounts of ether from alcohol with relatively little amounts of sulfuric acids found by Mitscherlich—Berzelius created the most important conception of catalysis and catalytic power.

Liebig, after having completed his most fruitful experimental period, published his work on agricultural chemistry. With wonderful intuition he discovered those important laws which today, nearly one hundred years later, are the unmoved pillars of an important science which has rendered the greatest of services to mankind. About his work on agricultural chemistry he said, "I have put a light in a dark room in which all kinds of furniture were present. My only merit is to have illuminated the room which was previously dark."

Vision plays the greatest rôle in the recent development of the modern nuclear physics. It may be sufficient to mention only a few names: Rutherford, Moseley, Langmuir, G. N. Lewis, Dirac.

LOGICAL THINKING

For the inventive scientist and technician, a large amount of logical thinking is necessary if he wants to make valuable discoveries and inventions. He must recognize the strength and weakness of contemporary knowledge. He must find the necessary new ways to correct the weak points of existing theories and constructions.

Many inventions have been made and are made daily through the logical application of natural laws. Haber studied the equilibrium between NH_3 and nitrogen and hydrogen with his collaborator Van Ordt. This was done at the same time that Nernst developed the third fundamental law of thermodynamics. With the knowledge of his day concerning the value of the integration constant, Nernst came to the conclusion that the experiments of Haber, carried out at 1000°C. and at normal pressure, must have been wrong. During a discussion, Nernst made the very remarkable proposition to carry out these experiments under increased pressure because, according to the Van't Hoff-Le Chatelier principle, the equilibrium must be shifted toward a much higher concentration of ammonia. He carried out these experiments with Jost at elevated pressures. From a certain standpoint it would be right to say that Nernst is the real inventor of the high-pressure synthesis of ammonia. Later on it was found that Nernst's integration constant was wrong, and Haber's results nearly right.

Nearly forty-five years have now elapsed since Diesel got his first patent on the Diesel machine. Diesel based his invention on logical application of known facts. He was sure that with the quick compression of air, its temperature would be raised above the ignition point of the fuel. The fuel should burn soon after its introduction, in a finely divided state, into the hot compressed air. It is known that the first experiment of Diesel showed that he was right, with one exception. He did not know that during the quick combustion of finely dispersed liquid fuel in the hot compressed air a

very strong increase in pressure must take place. One cylinder of his first engine exploded and it was only through a happy accident that Diesel was not killed.

Another example may be described in connection with the famous Müller patent for spinning of viscose rayon. The Müller patent was based upon an invention made with a young chemist named Köppke a little more than thirty years ago. Before this time, it was known that alkaline reacting viscose could be spun into sulfuric acid, but that the filament made with fresh acid did not have the good qualities which the old spinning bath gave. What happened? The alkaline viscose was neutralized by the acid, and sodium sulfate and sodium bisulfate were formed. Their presence in the old bath gave a quicker precipitation and a quicker removal of water from the highly swollen precipitated filaments. Müller and Köppke added neutral sulfate to the sulfuric acid from the beginning, imitating in this way the old used bath. From this day on the viscose industry developed to the great importance of today, and there is no doubt that this invention had, and has, enormous industrial and financial importance.

POWER OF OBSERVATION

This short story concerning the Müller patent shows that one of the most important requisites for making inventions is the power of observation. Many inventions and discoveries have been made by men possessing this power. Men like Scheele, Berzelius, Schönbein, and many others possessed this gift to a very remarkable extent.

Liebig also possessed this wonderful gift. In his autobiography, he tells us how he discovered, when he was twelve years old, how mercury fulminate could be made. A traveling tradesman in his small birthplace, Darmstadt, producing this material, used mercury and two liquids—one which formed nitrous gases and the other with which the tradesman eliminated all kinds of spots. The young Liebig knew that the first-mentioned liquid was nitric acid. He believed that the other liquid was alcohol, and he was right. There is no doubt that the twelve-year-old Liebig made experiments on mercury fulminate, and books tell us that he had to leave the high school and his position as a druggist when he was fifteen years old because he produced explosions of this dangerous explosive—it is said that Liebig recognized a preparation as allantoin, which his friend Wöhler sent him, because he had held this substance in his hands six years before. Emil Fischer also possessed this remarkable power of observation. He joked, saying that he could recognize the molecular weight of his preparations merely by looking at them.

In the first years that ammonia was produced on a large scale from its elements a very important source of trouble was discovered, coming from the incomplete removal of carbon monoxide from the reacting gases. More than traces of liquid organic substances were found in the reaction product. Mittasch studied this source of trouble, and, with his collaborators, found that the water gas which was present in the reacting gases under pressure in the presence of the alkalized iron as catalyst reacted with the formation of all kinds of lower and higher alcohols, aldehydes, and acids. The Fischer-Tropsch pressureless synthesis is a special, but important, example of this invention.

In this connection, the judgment of Emil Fischer concerning the very important life work of Peter Griess may be quoted. "Peter Griess was an experimenter of first rank. He owes his great success not to new, far-reaching ideas nor very happy combinations of ideas, but above all to his sharp observation and the consequent pursuit of phenomena." The writer believes that Emil Fischer did not completely recognize the extent and importance of Peter Griess' great invention in the field of diazo compounds.

DILIGENCE AND PERSISTENCE

Success in scientific and industrial fields is connected with diligence and persistence. When Newton was asked to what circumstances he owed his great scientific performances, he answered that it was through continuous thinking over the problems. We know from many successful solutions of technical problems that only this persistence could be victorious over all the great difficulties which present themselves at the beginning. When the writer visited him twenty-five years ago, Ernest Solvay said the following: "Had I known the great difficulties which I would have to meet in carrying out the ammonia soda process, and had I known that famous men like Dyar and Hemming, Schloesing, Bolley, and others had tried without success to find the solution of this problem, I would not have dared do this work." It may not be known that Ludwig Mond, the partner of Solvay, met enormous difficulties in putting the ammonia soda process into use, and only a happy accident prevented the closing of his plant. It is known that Solvay and Mond both died as extremely rich men, and that both gave large sums for further research work in different fields of science.

COMBINATION OF KNOWN FACTS

Many new and important advances are based on the combination of known facts. Before Pasteur created the new science of microbiology both the spread of diseases and the vitality of microörganisms were known. Pasteur combined these known facts. Long before Lavoisier's time, the balance was known. It was known before him that gases possessed weight. His great deed was to determine with the balance the increase in weight of metals after heating in air. A similar situation was found by Liebig in the field of agricultural chemistry. Many facts were known, but Liebig's great accomplishment was the combination of these known facts and the addition of other new facts which he discovered. Liebig did the same thing in physiology as in agricultural chemistry. Incidentally, Liebig is the foremost representative of a mixed type. In his youth he was a typical representative of the romantic type, but after his thirty-fifth year, he changed com-

pletely and became one of the most famous classical representatives of our science.

CURIOSITY AND CRITICAL SENSE

The presence of curiosity and of critical sense is very important in the progress of scientific and industrial work. It was curiosity which led the Babylonians more than five thousand years ago to study the starry sky. From astronomy the sciences of mathematics and of physics and later chemistry, were derived.

Einstein created his first theory of relativity when he was old, through new thinking over of classical problems in physics. He found that further progress could be made, and he started a new development in physics at nearly the same time that Planck, also equipped with critical sense, created his quantum theory.

It is known that the discovery of the rare gases by Lord Rayleigh and Ramsay was based on the fact that the specific gravity of nitrogen isolated from air was different from the specific gravity of nitrogen formed by the decomposition of chemical compounds like ammonium nitrite. The difference in the specific gravity of these two kinds of nitrogen was about .001. It led to the discovery of the rare gases in the air and in certain minerals by Ramsay. These discoveries have been described as a triumph of the third decimal. It is known that Birge and Menzel predicted from similar data the existence of heavy hydrogen, that Urey and Washburn discovered heavy hydrogen, and that G. N. Lewis found heavy hydrogen present to the extent of one part in five thousand parts of total hydrogen weight in normal water.

KNOWLEDGE OF FACTS AND LAWS

A certain amount of knowledge of facts and general laws in special fields is necessary, thus to avoid repetition of work which has been done. It is known that knowledge of too many facts is very often not favorable to creative work. Men like Moisson believed that knowledge of scientific literature above a certain optimum is sometimes more injurious than advantageous. One explanation of the fact that very often young brains find new and important things may lie in the circumstance that they are not overloaded with minor facts.

INFLUENCE OF HAPPENINGS IN YOUNGER YEARS

It is very interesting to see that often influences which have their roots in the youth have great importance for further work. It may be mentioned in this connection that Kekulé studied one year of architecture before he became a chemist, and that he attributed to his study of architecture his gift of seeing different things in space, leading him to the finding of the structural chemistry and the formula of benzene. Bessemer's activity in his youth in the field of metallurgy gives the explanation for his keen interest in this field and his success in later years. Pasteur's early work on tartaric acid led him to the study of fermentation and later on of diseases. Liebig's ancestors were farmers, and he had certainly heard in his youth discussion on farmers' questions at home, which may have led him afterward to his work on agricultural chemistry. By the way, his father was among those few men who made experiments on manure more than a century ago.

RARITY OF GIFTED PERSONALTIES

Gifted personalties are very rare. A well-known organizer of industrial work, F. W. Taylor, mentioned in the preface of one of his important books that a director tried to get a foreman possessing five or six different qualities. Taylor believed that with one quality the man would be a very good workman, with two qualities combined, a good foreman, with three qualities an excellent engineer, with four qualities a prominent leader of industry, with five qualities an outstanding personality, and with six qualities a genius. Le Chatelier discusses why men of genius are found relatively seldom. It is because a rare combination of several qualities must be found in one single individual. Somewhat changing the basis of Le Chatelier's calculation, we may see the following; if, for example, four qualities are needed and each quality could be found in one person among ten, then the probability that the four qualities could be found in one individual would be $1/10^4 = 1/10{,}000$. If in a capable man these four qualities are developed to such a high degree that each one could be found only in one person among fifty, then the probability of finding one person who would combine these four qualities in full development would be $1/50^4 = 1/6{,}250{,}000$. If we make a similar calculation for five qualities which may be found highly developed in persons of outstanding qualities, then only one individual among 312 millions fulfils this demand. The laws of probability show that persons of exceptionally great gifts can be found only very seldom.

The right education and early recognition of those individuals belonging to the intellectual elite of mankind is of greatest importance for the single nation and for the whole of mankind. The value of the life work of a Rembrandt, Newton, Beethoven, Shakespeare, Goethe, Liebig, and many others cannot be expressed in material values. Mankind is indebted to those great personalities for outstanding progress in so many different fields.

It may be fitting to conclude this study with words of Liebig from his famous chemical letters. Liebig says, "Innumerable germs of spiritual life fill the universe, but only in a few rare minds do they find the ground for their development. The idea of which nobody knows the origin becomes alive in them in the form of creative action."

EXPERIMENTAL SOAP MAKING

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MANY chemistry teachers have been attracted at some time in their teaching careers by the interesting possibilities of soap making. Attempts in this field in class laboratory work have generally produced very discouraging results, both in the products obtained and in the knowledge acquired. For many years the writer has persisted with laboratory classes in attempts to make soaps; and the conclusions are that a fair to a good grade of soap can be made by laboratory students, that almost any kind of organic oil or solid fat can be used, and that students enjoy the work.

The soaps produced from recipes given in chemistry manuals are generally so poor that there is no incentive for further work. The soaps made from soap book recipes are generally fair to good; but the reasons for including the ingredients and in the proportions given are obscure, and variations in the recipes may lead to poor results, making the teaching value questionable.

Common hard soaps are sodium salts of the organic acids found in animal and vegetable fats and oils as esters, while the soft soaps are the potassium salts. Some soaps are mixtures of the two salts. The acids are oleic, palmitic, stearic, butyric, lauric, arachidic, linolenic, linoleic, myristic, caproic, ricinoleic, isolinolenic, and many others in small percentages (*1*). The fats and oils are mixtures of the glycerol esters of these acids. In industry the fat or oil is frequently hydrolyzed and the glycerol and acids obtained before the soap is produced. The yields of glycerol from most fats are from ten to eleven per cent., but butter and cocoanut oil give much higher yields (*2*, *3*). If one had pure acids with which to make soaps, the chemical reactions would be known and the quantities of materials required could be stated exactly.

In soap making there are many complicating factors which prevent the figuring of accurate recipes. Some of these factors are that fats and oils are usually rancid to some extent, they vary greatly in composition, and they have variable amounts of unsaponifiable material in them. Vegetable oils may vary because of variation in the soil, the climate, the seasons, and the varieties of the plants. There are similar variations in animal oils and fats. In making modern, milled, salted-out soaps, all these factors can be neglected because the lye is always used in excess, and the excess is finally eliminated. In making small samples of soap in the laboratory the salted-out process is not undertaken easily and these factors must receive some consideration.

While a soap is the product of a chemical combination of a saponifiable oil, fat, or resin with a base, in practice only NaOH or KOH are the bases used. This is because some bases produce insoluble soaps, *e. g.*, $Ca(OH)_2$, some are too expensive, *e. g.*, LiOH, and some do not work well, *e. g.*, NH_4OH. We have made in the laboratory fully a thousand kinds of soap by altering the oils, the bases, the fillers, and their proportions. We have used the following oils and fats: lard, beef tallow, mutton tallow, corn oil, cottonseed oil, olive oil, butter, peanut oil, palm oil, linseed oil, chicken oil, cocoanut oil, goose grease, duck grease, turkey oil, bear grease, cocoa butter, artificial butter, tung oil, rapeseed oil, soy-bean oil, sesame oil, and castor oil. Other materials used were rosin, water glass, sal soda, borax, hydrochloric acid, alcohol, cane sugar, gum tragacanth, sodium hydroxide, potassium hydroxide, ammonium hydroxide, coloring materials, and perfumes.

For class work it has been found best to keep one strength of lye on hand, and since manufacturers use the Baumé hydrometer scale for measuring we have followed their practice. The NaOH used is 30° Bé. at 15.5°C. The density is then 1.261 and the solution contains 0.2961 g. of NaOH per ml. For titration, one ml. of this solution requires 74 ml. of 0.1 *N* acid (*4*, *5*).

The KOH should be chemically equivalent to the NaOH. That is, one ml. of KOH should require 74 ml. of 0.1 *N* acid. At this strength, at 15.5°C., will be 34° Bé. or sp. gr. 1.305, and will contain 31.5 per cent. KOH or 0.415 g. per ml. (*6*). Lye titrated at this strength may read 36° Bé. due to impurities or other causes, so titration is essential. The common lyes are good enough for soap making, but they always contain chlorides, carbonates, and water. For crude work the Baumé test at 15.5°C. can be used.

A solution of NaOH at 30° Bé. is too strong to saponify most fats and oils to the best advantage and too weak for some others, *e. g.*, cocoanut oil. Dilution of the lye is generally desirable. Beef tallow is said to saponify best at 10° to 12° Bé. and cocoanut at 36° Bé. (*7*). Diluting 1 ml. of 30° Bé. NaOH with 1 ml. of water gives 16.9° Bé., with 2 ml. of water 13.2° Bé., and with 3 ml. of water 10.5° Bé.

Alkali saponification tables are given in many books (*8*, *9*, *10*).

If the table is given for KOH and stated in milligrams it means the number of milligrams of pure KOH per gram of fat or oil. The table may be in percentages and called an alkali saponification or absorption table.

This table gives the percentage of lye required to saponify any quantity of the oil. For good results in laboratory work on a small scale it seems necessary to add approximately twenty-five per cent. more lye.

To make a small test bar of soap that can be handled in a 150- to 250-ml. beaker, 50 ml. of oil is sufficient. To save time, fats should be melted and measured, and not weighed. The following table illustrates the method of calculating the NaOH.

TABLE 1

	Density	*Weight of 50 ml.*	*Alkali absorption NaOH*	*NaOH required for 50 ml.*	*30 Bé. NaOH required to saponify 50 ml. oil.*
Beef tallow	0.949	47.45 g.	13.9%	6.596 g.	22.3 ml.
Lard	0.936	46.8 g.	13.8%	6.458 g.	21.9 ml.
Cocoanut oil	0.926	46.3 g.	17.6%	8.149 g.	27.5 ml.
Cottonseed oil	0.922	46.1 g.	13.8%	6.369 g.	21.5 ml.

The last column is obtained by dividing the next to the last column by the amount of NaOH in one ml. of 30° Bé. or 0.2961 g. For 50 ml. of oil it generally requires from 21.5 to 22.5 ml. of 30° Bé. NaOH for saponification, but castor oil is low (20.4 ml.) and cocoanut oil (27.5 ml.) and butter (25.6 ml.) are exceptionally high.

Soaps can be classified by the process used in making them as boiled, semi-boiled, cold process, transparent, and liquid. In the last four named, the ingredients are all left in the soap so the lye must be figured accurately or the excess neutralized. In a boiled soap the lye is always used in excess, and the soap is then salted out and separated from the excess lye. The above figures take into consideration the unsaponifiable material found in all fats and oils which varies from a few tenths of one per cent. to about 2.8 per cent. (*11*).

So much for the figures. In making a transparent soap it is necessary to figure closely, or, better, to know from practice, the proportions of the materials to use, since there is no chance to rework the soap when once made. Semi-boiled soaps are readily made in the laboratory, because they can be reworked without waste any number of times. In practice 26 to 28 ml. of lye, 30° Bé. NaOH or 34° Bé. KOH can be used for 50 ml. of oil unless much of the oil is cocoanut or butter. This is about a twenty-five per cent. excess of lye, but the excess seems to be neutralized by remelting and beating this small sample in contact with the carbon dioxide of the air.

Saponification is generally a slow process. On a manufacturing scale for boiled soaps in many ton lots, the soap is often boiled for two weeks (*12*). Cocoanut oil is easily and rapidly saponified, while the tallows are saponified with difficulty. If easily saponified oils are mixed with difficultly saponified ones, the time of saponification is greatly reduced. Rancidity increases the speed of saponification. Some manufacturers use catalysts to speed the action, but we have never used them. Alcohol as a solvent hastens saponification, but in making small quantities of soap most of the alcohol is lost and the part that is retained seems to be detrimental. Cold process and transparent soaps are easily and quickly made because of the high content of cocoanut oil. These soaps are never neutral because small globules of both fat and lye fail to come into contact, and remain unsaponified. For transparent soaps alcohol or sugar is necessary.

General directions for a small test bar are as follows: Heat all the oils and fats together in a 250-ml. beaker till they are intimately mixed and the temperature is from 30° to 50°C. Be careful of overheating. Fats that have been heated till black smoke comes from them never seem to make good soap. Pour the water called for into the lye; then pour the mixture, a little at a time, stirring constantly, into the oils. If foaming occurs when the first lye is added, go very slowly. Mix the materials thoroughly for several minutes and cool. A solid mass of soap or three layers of materials may be obtained. If the materials are in layers, the lower layer is water and lye, the middle layer is soap, and the upper layer is fat or oil. When the materials are cold stir them together until the mass is nearly solid; then set the beaker away for a day. Prolonged stirring is unnecessary, for saponification may take several days unless a large percentage of cocoanut oil is present. Next day loosen the soap from the beaker with a small spatula, take the bar out, turn it over in the beaker, and remelt with a low heat. If it is difficult to remove the bar from the beaker, warm the bottom and strike the beaker mouth down on the palm of the hand. Do not lose any of the material. When the soap has been melted and thoroughly mixed set the beaker away for another day. After remelting the bar is always turned over in the beaker because the lye tends to settle in the bottom.

This remelting process will have to be repeated for several days until the soap tests nearly neutral. Soapmakers test by tasting. As all soaps are antiseptic, tasting is not harmful. Do not taste soap until it has been remelted several times, for the lye will be too strong. Taste the middle of the bar, for the bottom nearly always tests for lye, and the top is often greasy. If free lye is present a sharp taste can be noticed instantly. All soap will taste soapy after two or three minutes on the tongue. Dry soap can be tested with an alcoholic solution of phenolphthalein. If free lye is present a red color can be seen quickly. Phenolphthalein is nearly worthless for testing wet soap or hot soap just being made. A good toilet soap should be neutral, but laundry soap will often test for excess lye.

When a small piece of soap is heated on a paper, a grease spot indicates excess oil. Excess oil will finally become rancid and produce bad odors and dark colors unless the excess oil is lanoline. Lanoline is commonly used in good grades of toilet soaps to give a velvety feeling and a nice appearance. Lanoline is not saponifiable by ordinary soap-making processes. Excess lye, even in small quantities, is irritating to a delicate skin and is avoided by all toilet soap makers. Soaps, however, do not lather well in hard waters unless there is a slight excess of lye. Gum tragacanth can be added to aid the lathering qualities. A slight excess of fat

is very undesirable, because it calls for more perfume.

There are several methods of neutralizing soaps in the laboratory. (1) By beating the soap in a beaker with a stirring rod the carbon dioxide of the air will slowly combine with the excess lye, forming sodium or potassium bicarbonates. This effect comes from remelting and beating several times. The beating whitens and improves the texture of the soap. (2) A little coconut oil can be added and mixed thoroughly. This oil saponifies readily, but care should be used not to get an excess. (3) The soap can be shaved into fine pieces, exposed to the air on a glass plate for two or three days, and remelted. This gives the carbon dioxide of the air a chance to act on the whole mass. (4) We have added to our small samples after remelting from 5 to 10 ml. of 3 *N* HCl. This greatly whitens the soap but adds NaCl or KCl. In small quantities these salts do not seem to injure the soap, but large amounts cause the bars to crack and also prevent good lathering. In some cases neutralization by acid does not seem to work.

It is desirable to give each student in a class a different soap recipe, and this can be accomplished easily by using symbols. These letters or symbols enable the teacher to write many recipes quickly and to check the results accurately and quickly. A list of some soaps that will work well and the type of symbols, with explanations, follows:

1. eP jA iB
2. tP tO fA fS gE fR
3. iP vO iA iS gI gF
4. jP dE gB fR (Cold Process)
5. fP fO iF jE fS aZ eR oU (Transparent)
6. fP gO fE gF fB eR

The small letters stated in ml. are e, 30, j, 35, i, 15, t, 13, f, 20, g, 10, v, 12, d, 40, a, 25, and o, 25 gs. The capital letters are P, sodium hydroxide, O, potassium hydroxide, A, lard, B, beef tallow, S, mutton tallow, E, cocoanut oil, R, distilled water, I, butter, F, castor oil, Z, denatured alcohol, and U, cane sugar.

In Soap Number 4 use just enough heat to melt the fats; then pour in the lye and stir thoroughly. In a day this should be fair soap. In Soap Number 5, heat the first five ingredients nearly to boiling in a double boiler or a pan of water, with stirring. Put the last three ingredients together and stir well; then add this to the first batch. Stir well. This should give a clear, transparent, liquid that will remain clear when cold. Water glass made up to 30 Bé. can be added to any soap in small quantities with good results, but it should be added on one of the remelts, for it neutralizes some lye.

After several remeltings of the soap one may encounter several difficulties. If the soap is grainy, like corn meal, add 20 to 40 ml. of water and remelt. If the trouble is not due to a large excess of lye the soap will come out all right. If the soap remains liquid in small bulk and does not harden, add 20 to 40 ml. of water, reheat and, strange to say, it will generally harden. When well saponified the soap will string out in long hair-like threads from a stirring rod, and look quite clear.

All water used should be distilled. Water, when used, should be added to the lye. When rosin is used it should be powdered and added to the oils. Water glass, or any other filler, should not be added till the soap is neutral or nearly so. Water glass hardens and whitens soap (*13*). Soap can be made very stony by excess water glass, but 20 to 30 ml. of 30° Bé. water glass added to a sample of soap containing 50 ml. of oil will not injure the soap. Sal soda and borax tend to harden and whiten the soap and soften the water. These fillers, when added sparingly, will generally improve the soap, but in large quantities are harmful.

The yield of soap, without fillers, is about one gram of soap for one gram of oil. Cocoanut oil gives a much better yield. With water glass, sal soda, and salt, coconut oil will yield three grams of soap to one gram of oil (*14*). Since the yield of soap is increased by fillers, the amount of fillers used is limited only by the conscience of the soap maker (*15*).

Poucher (*16*) says that a high quality soap should contain tallow, lard, cocoanut oil, palm kernel oil, and castor oil. All soap makers agree that a high grade soap can not be made without tallow—beef tallow preferred. Castor oil and cocoanut oil perform wonders when added to a lard and tallow soap. Lanoline and glycerine are valuable ingredients in good soaps. Shaving soap makers seem to agree that some of the lye should be KOH.

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A MOLECULAR-WEIGHT DETERMINATION *for* FRESHMEN

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CONVINCED by past experiences that most students leave general chemistry with rather vague ideas about partial pressures, the author of this paper decided to adopt a modification of the steam distillation process as a freshmen laboratory experiment. Preliminary experiments showed that the modified process could easily be carried out with a fair degree of precision, and that the quantitative results could be used by students with little training to calculate the molecular weight of the immiscible organic liquid being distilled.

Students apparently have little trouble in applying the law of partial pressures to mixtures of ordinary gases. When it comes to applying this same law to the distillation of liquids most of them lose their way. The statement that the partial pressure of each liquid is proportional to the number of molecules of that liquid present *in the vapor state* is misapplied, usually because the student overlooks the fact that the statement refers to the vapors and not to the liquids.

Following a discussion of partial pressures the students are given mimeographed directions for determining the molecular weight of organic liquids immiscible with water. The setup is simply that used for ordinary downward distillation. Graduated cylinders ordinarily used to receive the distillate are replaced by 100-ml. volumetric flasks. Experience has shown that many of the organic liquids do not separate readily from water, and the degree of precision with which one can read a volume with a 100-ml. graduated cylinder leaves much to be desired. In this laboratory the two weighings are done by an assistant using an analytical balance, but there is no apparent reason why a good Harvard trip balance could not be used. Very good results have been obtained using carbon tetrachloride, bromobenzene, *n*-butyl bromide, aniline, and nitrobenzene. Other liquids immiscible with water should serve equally well, provided the liquid has a density considerably more or considerably less than that of water. Many freshmen obtain molecular weights within a range of two or three per cent. error. The following directions are given to students.

MOLECULAR WEIGHT BY STEAM DISTILLATION

Principles involved.—(*a*) Law of partial pressures. (*b*) Relations between mass, density, volume.

Apparatus.—Liter distilling flask, 100-degree thermometer, condenser and tubing, 2 ring stands, 1 ring, condenser clamp, small clamp, 100-ml. volumetric flask, water bath.

Materials.—Carbon tetrachloride (chloroform, bromobenzene, aniline, *n*-butyl bromide, or nitrobenzene may also be used).

Procedure.—1. Set up a distillation outfit like the one already set up in the laboratory. Roll your corks to soften them and see that there is no leak around the thermometer or between the distilling flask and the condenser. The steam bath may be left off if the liquid to be studied is a high boiling one such as aniline, nitrobenzene, or *n*-butyl bromide or bromobenzene, but if the steam bath is left off care must be taken to avoid superheating of the lower layer. In any case the boiling point of the mixture will be below the boiling point of pure water. (Why?)

2. Weigh the volumetric flask and record the weight (*B*).

3. Place in the distilling flask, using a funnel, about 200 ml. carbon tetrachloride and 600 ml. water.

4. Wrap a towel around the upper part of the distilling flask to reduce heat loss and heat the steam bath just enough so that the mixture distils drop by drop. (If the steam bath is not used, heat the flask with a low flame.) Discard the first 10 ml. that distils and continue the distillation till exactly 100 ml. of the distillate has been collected. Record the temperature at which the mixture boils (*E*).

5. Weigh the flask and the distillate and record the weight (*A*). Use the thermometer in the distilling outfit to obtain the temperature of the distillate immediately after weighing it. Record this temperature (*H*).

6. Record the barometer reading (*D*).

7. Obtain data for (*F*) and (*I*) from a handbook of chemistry and ask an assistant or the instructor for the density (*J*).

Data:

A—Weight of flask and distillate.....
B—Weight of flask.....
C—Weight of distillate ($A - B$).....
D—Barometer reading.....
E—Boiling point of mixture.....
F—Vapor pressure of water at temperature *E*.....
G—Vapor pressure of organic liquid at *E*.....($D - F$).....
H—Temperature of collected distillate.....
I—Density of water at temperature *H*.....
J—Density of organic liquid at *H*.....
K—Grams of water collected (calculate).....
L—Grams of organic liquid collected ($C - K$).....
M—Number mols water collected ($K \div 18$).....
N—Number mols organic liquid collected (calculate).....
O—Molecular weight of organic liquid ($L \div N$).....
P—Percentage error (error $\times$ 100 $\div$ true mol. wt.).....

Calculation of K:

Let X = no. ml. water
$100 - X$ = no. ml. organic liquid
$J(100 - X)$ = no. g. organic liquid
IX = no. g. water
$IX + J(100 - X) = C$
Solve for X
$K = IX$

Calculation of N:

$$F \div M = G \div N$$

The ORGANIC CONTENT *of* TWELVE COLLEGE GENERAL CHEMISTRY TEXTBOOKS

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THE Committee on Correlation of High-School with College Chemistry has repeatedly published suggestions and outlines to aid in the correlation of high-school and college chemistry (*1*). The "Standard Minimum First-Year College Course in Chemistry,"[1] published in 1927, appears to be the most recent outline available for the aid and direction of college instructors. The recommended basic material in this college syllabus has been organized under eleven major topics, one of which deals with the "Carbon Group."

This major division dealing with the carbon group has, in turn, been subdivided into three sections entitled, "Introduction," "Hydrocarbons," and "Derivatives of Hydrocarbons." The introduction includes a review of work on carbon, table showing the relation of carbon to silicon, the reason for the existence of so many organic compounds, a consideration of homologous series, and the electronic conception of valence as applied to organic compounds. The second section dealing with hydrocarbons includes a suggested study of methane, ethylene, acetylene, petroleum, benzene, and toluene. The third part, concerning derivatives of hydrocarbons, covers the topics of alcohols including methyl, ethyl, and glycerine; aldehydes, especially formaldehyde and acetaldehyde; acetone; acids such as formic and acetic; esters; fats; soaps; carbohydrates, with emphasis upon sugars and cellulose; and foods including a study of vitamins, digestion, and food values. This portion of the outline dealing with carbon and its compounds is identical with that published in the suggested course in 1924.

The author's findings in a previous study[2] concerning the organic content of twelve high-school chemistry textbooks has prompted this related study in the field of college general chemistry textbooks. A page-by-page examination has been made of the following twelve representative college general chemistry textbooks. Each text in this list has been given an alphabetical designation which has been used in Table 1, to indicate this same textbook.

(*A*) BOND, PERRY A., "The fundamentals of general chemistry," Farrar & Rinehart, Inc., New York City, **1935**.
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(*K*) MCPHERSON, WILLIAM, AND WILLIAM EDWARDS HENDERSON, "An Elementary Study of Chemistry," Ginn and Co., New York City, **1934**.
(*L*) SCHLESINGER, H. I., "General chemistry," Longmans, Green and Co., New York City, **1930**.

A tabulation was made of the type and amount of organic material contained in each of the twelve college general chemistry textbooks. The same general criteria and practices were used in arriving at final values as were used in the previous study.[2] This seems to be particularly desirable so that a fair comparison can be made between the two investigations. The results of this study are arranged in Table 1.

An examination of the data in Table 1 shows that the number of pages devoted to organic material, as classified in this study, varies from one hundred twelve to thirty and from 15.8 to 6.6 per cent. in the twelve representative college chemistry textbooks. The average number of pages is 82.4 and the mean is 93. The average and mean percentages are 12.3 and 12.5, respectively. However, it should be mentioned that the point of view and purpose of the several authors has noticeably affected the organic content of many of the textbooks included in this study.

For example, Deming's "Introductory College Chemistry," is divided into four major divisions covering preliminary items, the non-metals, the metals, and organic chemistry. The organic section alone contains thirty-four pages and deals with the chief types of organic compounds, some organic syntheses, and the chemistry of nutrition and hormones. More than usual space is given in this volume to topics that prom-

[1] GORDON, N. E., *et al.*, "Correlation of high-school and college chemistry," J. CHEM. EDUC., **1**, 33–4, 87–99, 158–60 (1924); **2**, 46–8, 269–75 (1925); **4**, 640–56 (1927); **5**, 1627–33 (1928; and **13**, 175–9 (1936).

[2] DUNBAR, R. E., "The organic content of twelve high-school chemistry textbooks," *ibid.*, **14**, 115–17 (1937).

TABLE 1

PAGES OF ORGANIC MATERIAL IN TWELVE COLLEGE GENERAL CHEMISTRY TEXTBOOKS

Textbook Designated by	*F*	*K*	*J*	*H*	*G*	*I*	*C*	*E*	*L*	*B*	*A*	*D*	*Total*	*Avg.*	*Mean*
CO_2, CO, Carbonates, Carbides, CS_2, etc.	18	26	14	17	19	15	27	9	15	15	5	13	193	16.1	15
Hydrocarbons	9	22	8	23	15	19	22	19	17	13	3	6	176	14.7	17
Carbon, Diamond, Coal, Graphite, etc.	25	10	9	5	11	22	15	7	8	3	7	12	134	11.2	10
Carbohydrates	3	11	6	18	8	12	10	14	3	3	2	1	91	7.6	10
Foods and Digestion	8	3	6	12	9	1	3	4	3	1			50	4.2	3
Alcohols, Ethers	3	6	3	6	3	4	6	3	8	3	2	1	48	4.0	3
Plants and Soils	2	6	12	6	6	3	2	5	1	1		1	45	3.8	3
Fats and Soaps	2	7	9	5	4	3	4	2	2	1	2	1	42	3.5	3
Aldehydes and Ketones	4		1	3	3	2	3	3	5	1	2		27	2.3	3
Organic Acids	1	3	1	1	2	2	2	2	6	1	1	2	24	2.0	2
Esters	1	1	2	1	2	3	1	1	3	1	1		17	1.4	1
Proteins	1	1	1	1	3		1	1	2			1	12	1.0	1
Miscellaneous, Experiments, etc.	16	16	13	8	11	9	11	15	16	8	5	2	130	10.8	11
Total Organic Pages	93	112	85	106	96	95	107	85	89	51	30	40	989	82.4	93
Total Pages	590	729	555	700	653	757	872	769	847	565	411	609	8057	671.4	700
% Organic Material	15.8	15.4	15.3	15.1	14.7	12.5	12.3	11.1	10.5	9.2	7.3	6.6		12.3	12.5

ise opportunity for the student to put his chemistry to real use in everyday life. Water softening, ventilation, the economic use of fuels, household refrigeration, and the principles of human nutrition are examples of the effort toward that end. By short-cutting preliminaries the student is brought to a study of the compounds of carbon, nitrogen, and sulfur within a few weeks of the beginning of the course. Because of this approach and point of view the organic content runs higher than in many of the other texts surveyed, although it should be mentioned that the relatively small number of pages in this volume, as compared to many of the others, has also contributed to its high organic percentage.

McPherson and Henderson in, "An Elementary Study of Chemistry," devote six of their forty-seven chapters to a consideration of carbon and its compounds. Kendall's "Smith's Introductory College Chemistry," contains seven chapters dealing with carbon and organic substances out of a total of forty-six. These two texts rank second and third, respectively, in percentage of organic material.

Holmes in his "General Chemistry" offers no apology for the inclusion of a considerable amount of descriptive chemistry. He states that extremists would make general chemistry a mere preparation for advanced physical chemistry, forgetting that it is also a preparation for analytical and organic chemistry, for medicine and industry, and a way to broad culture for the entire class. The organic content in this textbook runs relatively high again, 15.1 per cent.

While Deming's, "General Chemistry," also contains four major divisions dealing with general principles, the nonmetals, the metals, and organic chemistry, yet the organic content runs noticeably lower than in the other Deming text. The two books, of course, are designed for distinctly different purposes. The five chapters in the organic chemistry section dealing with hydrocarbons, the cellulose industries, other industries based on plant and animal products, how chemical formulas are derived, and some synthetic products, cover a total of sixty-eight pages. Deming states that though the course may well begin by being largely descriptive, general principles should receive chief emphasis in the end. This attitude and purpose of the author has noticeably decreased the organic content of this volume as compared to the other text by the same author.

The point of view and development of the subject matter in the texts by Schlesinger, Brinkley, Bond, and Cartledge is predominately that of the inorganic or physical chemist. As a result the organic percentage runs the lowest in these four texts of the twelve volumes surveyed. This conclusion seems justified from a representative statement taken from the preface of Bond's "The Fundamentals of General Chemistry." "It has seemed to the author that the time has come for a rearrangement of subject matter so that emphasis may be placed upon the fundamentals of theory and of law with descriptive chemistry as example rather than as prime object." Schlesinger, in the preface to the second edition of his "General Chemistry," indicates, among other major changes in the preparation of this newer edition, a complete rewriting of the chapter on organic chemistry and its expansion to three. And yet the organic content is noticeably lower than many of the other representative texts included in this study.

It is probably to be expected that a greater variation in the content of college general chemistry textbooks would be found than in corresponding high-school books. The college texts are designed for a far greater variety of conditions and classes. More extensive and separate courses in organic chemistry are usually offered or required of chemistry majors and as a prerequisite for numerous professional courses. The Committee on the Correlation of High-School with College Chemistry undoubtedly had these facts in mind when they recommended far more organic material for the standard minimum high-school course in chemistry than for the corresponding standard minimum first-year college course in chemistry.

While no direct reference is made in any of the twelve representative college general chemistry textbooks to this minimum course in chemistry, yet there is a surprisingly uniform and consistent coverage of the suggested topics, exceptions possibly being for aldehydes,

ketones, esters, foods, vitamins, digestion, and food values. The topics of carbon dioxide, carbon monoxide, carbonates, carbides, etc., which at best are only semi-organic in nature, again claim first place in importance. The subject of hydrocarbons occupies second rank. The subject of carbon and its various allotropic forms, again only semi-organic in nature, is third in importance. Other topics in order include carbohydrates, foods and digestion, alcohols and ethers, plants and soils, fats and soaps, aldehydes and ketones, organic acids, esters, and finally proteins.

A comparison with the previous study (*2*) is particularly interesting. This comparison is facilitated by the tabulated data in Table 2.

TABLE 2

A COMPARISON OF THE ORGANIC CONTENT OF TWELVE HIGH-SCHOOL AND TWELVE COLLEGE GENERAL CHEMISTRY TEXTBOOKS

	High-School Texts				College Texts			
Pages Devoted to Following:	*Maximum*	*Minimum*	*Average*	*Mean*	*Maximum*	*Minimum*	*Average*	*Mean*
CO_2, CO, Carbonates, Carbides, CS_2, etc.	47	13	24.0	20	27	5	16.1	15
Hydrocarbons	39	6	17.3	15	23	3	14.7	17
Carbon, Diamond, Coal, Graphite, etc.	24	6	16.2	13	25	3	11.2	10
Carbohydrates	33	4	13.2	13	18	1	7.6	10
Foods and Digestion	66	0	19.2	11	12	0	4.2	3
Alcohols, Ethers	9	2	4.8	4	8	1	4.0	3
Plants and Soils	157	2	21.6	9	12	0	3.8	3
Fats and Soaps	18	0	7.3	6	9	1	3.5	3
Aldehydes and Ketones	3	0	1.3	1	5	0	2.3	3
Organic Acids	6	1	2.6	2	6	1	2.0	2
Esters	6	0	2.1	1	3	0	1.4	1
Proteins	14	0	3.8	1	3	0	1.0	1
Miscellaneous, Experiments, etc.	109	1	18.1	9	16	2	10.8	11
Total Organic Pages	328	65	152.0	115	112	30	82.4	93
Total Pages in Texts Studied	777	446	606.1	588	872	411	671.4	700
% Organic Material	58.6	11.4	25.1	19.8	15.8	6.6	12.3	12.5

Here it will be noted that the organic content of the high-school textbooks, in general, runs much higher than that of the corresponding college texts, the maximum number of pages being three hundred twenty-eight and one hundred twelve or 58.6 per cent. and 15.8 per cent., respectively, and the minimum sixty-five and thirty pages or 11.4 per cent. and 6.6 per cent., respectively. The average, of one hundred fifty-two pages or 25.1 per cent and mean, of one hundred fifteen pages or 19.8 per cent. for the high-school volumes contrasts with an average of 82.4 pages or 12.3 per cent. and a mean of ninety-three pages or 12.5 per cent. for the college texts. The maximum, average, and mean number of pages in the college textbooks is distinctly greater than those of the high-school field, while the minimum sized college text is some thirty-five pages smaller than the corresponding high-school book.

The order of importance of the various organic topics in the high-school and college texts is essentially the same if the mean values are taken as the standard for comparison, exceptions being the pages devoted to alcohols—ethers and aldehydes—ketones, for the high-school textbooks. The values for the average number of pages produce a far greater discrepancy, due largely to the influence of some three high-school texts, which are probably not as representative as the other twenty-one texts considered.

CONCLUSIONS

The results of this study indicate that:

1. There is a surprisingly consistent uniformity in the organic content of these twelve representative college general chemistry textbooks.
2. College general chemistry textbooks that emphasize the theoretical, inorganic, or physical aspects of the science usually contain the least pages devoted to organic material.
3. The subjects of aldehydes, ketones, organic acids, esters, and proteins command least attention in these twelve college general chemistry textbooks.
4. Aliphatic topics receive far more space and attention than aromatic topics.
5. The topics for the "Standard Minimum First-Year College Course in Chemistry," are reasonably well covered in most of the twelve textbooks studied, exceptions probably being noted in the case of aldehydes, ketones, esters, foods, vitamins, digestion, and food values.
6. College textbooks are consistently larger than the corresponding high-school texts, designed for courses in general chemistry.
7. College texts in general chemistry contain a higher percentage of theoretical material[3] than the corresponding high-school books.
8. The organic content of the college general chemistry textbooks is noticeably lower than those of the high-school field.
9. The emphasis on individual organic topics as compared to the organic content as a whole in both high-school and college general chemistry textbooks is surprisingly uniform.

[3] CORNOG, J. AND J. C. COLBERT, "What we teach our freshmen in chemistry," J. CHEM. EDUC., **1**, 5–12 (1924).

Nature is so varied in her manifestations and phenomena, and the difficulty of elucidating their causes is so great, that many must unite their knowledge and efforts in order to comprehend her and force her to reveal her laws.
—LAPLACE

The BEHAVIOR *of* CHROMIUM ACETATE *in* QUALITATIVE ANALYSIS

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In the presence of acetate ion and the absence of other trivalent metals, chromium is not precipitated as the hydroxide on addition of ammonium hydroxide. The effect of this behavior on the qualitative detection of chromium has been studied.

✦ ✦ ✦ ✦ ✦ ✦

THE INTERFERENCE of the acetate ion with the usual qualitative test for chromium was first brought to the attention of one of us by a student who failed to obtain a precipitate from an iron-zinc group unknown which obviously contained chromium. The material was found to be pure chromium acetate. Other samples of the compound likewise yielded no precipitate with NH_4Cl and NH_4OH. A further test was immediately made on a mixture of sodium acetate and potassium chromium sulfate. Again no precipitate was obtained, but the color of the solution changed from green to violet. With ammonium hydroxide alone, an incipient precipitate appeared to form, but it quickly redissolved with development of the violet color. Examination of the available textbooks of elementary qualitative analysis revealed no mention of the phenomenon. More comprehensive works on qualitative and quantitative analysis were only a little more helpful. A number of authors give no information beyond the simple statement that chromium forms no basic acetate. Fales[1] summarizes the various opinions by saying that the behavior of chromium in the basic acetate separation is a matter of dispute. Noyes and Bray[2] add that chromium is completely precipitated with other basic acetates if the amount of iron present is two hundred times as great as the quantity of chromium. A survey of the literature indexed by *Chemical Abstracts* yielded little of value except the composition and manner of preparing a few complex compounds which contain chromium ammonium and acetate. The questions of greatest interest to students and teachers of qualitative analysis remained unanswered. We have accordingly made a short investigation to determine the minimum quantity of acetate which will interfere with the usual procedure for identifying chromium, the possible effect of other ions, and a suitable modification of the standard procedure that would overcome the interference.

Tests were made on half-normal solutions of chromium acetate, chromium sulfate, and the nitrates or chlorides of all the other metals of the iron-zinc group, the alkaline earths and magnesium. As these solutions were mixed or diluted before the addition of the precipitating agent, the concentration of the metal ions ranged from 0.1 to 0.3 normal. This is essentially the range of concentration usually specified for qualitative tests. The ammonium hydroxide and acetic acid solutions were three normal. Two series of tests were made on solutions of chromium sulfate to determine the amount of acetate that would interfere with precipitation of chromium hydroxide. A solution mixed in the ratio of one atom of chromium, three mols of acetic acid, and six mols of NH_4OH yielded a small precipitate which redissolved on standing. The initial precipitate was lighter when the chromium salt and the acetic acid were mixed and allowed to stand a few minutes before the NH_4OH was added than when the three solutions were mixed rapidly. A mixture in the ratio of one atom of chromium, two mols of acetic acid, and five mols of NH_4OH yielded a slight precipitate and a filtrate which showed the violet color characteristic of the ammonium chromium acetate complex. With one mol of acetic acid for each atom of chromium, precipitation was incomplete, but sufficient to enable a careful worker to obtain a satisfactory confirmatory test. Addition of ammonium chloride or an excess of ammonium hydroxide favored the formation of the complex and decreased the quantity of precipitate. These observations on the effect of ammonium ion were further confirmed in the next series of tests which showed that precipitation of chromium was practically complete if ammonia was added immediately after mixing sodium acetate and chromium sulfate. Substitution of sodium hydroxide or sodium carbonate for a part of the ammonia theoretically required did not increase precipitation.

The effect of iron was next investigated. A standard solution was prepared by weighing the necessary amount of ferrous ammonium sulfate and oxidizing it with bromine water in the presence of sulfuric acid.

[1] FALES, H. A. "Inorganic quantitative analysis," The Century Co., New York City, 1925.

[2] NOYES, A. A. AND W. C. BRAY, "A system of qualitative analysis for the rare elements," The Macmillan Co., New York City, 1920.

A mixture of this solution with chromium acetate in the ratio of one atom of iron to one of chromium yielded a pale violet filtrate and a precipitate which contained chromium hydroxide. The precipitate of basic ferric acetate, which formed on boiling the solution before the ammonium hydroxide was added, also contained chromium. Two atoms of iron for each mol of chromium acetate effectively prevented the formation of the complex compound and permitted complete precipitation of both metals by ammonia. Complete precipitation was also obtained with a ratio of three atoms of iron to two of chromium. This is just the amount of iron theoretically required to bind all of the acetate ion as basic ferric acetate. The tests were repeated with aluminum instead of iron and exactly the same results were obtained. It does not follow, however, that these two elements in mixture with chromium acetate would produce student unknowns of equal difficulty. Under the prevailing system of preparing unknown solutions to contain ten milligrams of each ion per cubic centimeter of solution, the molar concentration of aluminum is twice that of chromium and sufficient to bring about complete precipitation. The concentration of iron is slightly less than that of chromium and the latter element may not be completely precipitated. Divalent ions, as might be expected, had no effect on the precipitation of chromium.

The interfering acetate ion was easily removed by adding hydrochloric acid to the test solution and evaporating to dryness. It is possible that boiling the filtrate from the second group to remove hydrogen sulfide would remove most of the acetate, but this is uncertain. It is important that a note should be added to qualitative directions so that students will test for acetate as well as phosphate before attempting the precipitation of the iron-zinc group.

Certain difficulties occasionally encountered in the removal of phosphate are also to be explained by this anomalous behavior of chromium. Chromium is usually found in the precipitate with iron and aluminum, but on rare occasions, it appears in the filtrate. Precipitation is undoubtedly complete if the amount of phosphate is sufficient to combine with all of the trivalent metal ions present. However, addition of a large excess of ammonium acetate to a solution that contained a relatively small quantity of phosphate would tend to keep the chromium in solution.

An ELEMENTARY LABORATORY EXPERIMENT INVOLVING *the* HOFMANN REARRANGEMENT

THE PREPARATION OF METHYLAMINE HYDROCHLORIDE FROM ACETAMIDE BY MEANS OF CALCIUM HYPOCHLORITE

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THE well-known Hofmann reaction by which an amide, in the presence of chlorine or bromine and an alkali, is converted into a primary amine with one less carbon atom, is of considerable interest in organic chemistry. The reaction may be used in going "down series," and it serves as a laboratory method for the preparation of a primary aliphatic amine. The reaction is of interest also because it involves a molecular rearrangement.

The Hofmann reaction is often illustrated in the laboratory by the preparation of methylamine hydrochloride from acetamide. It has been our experience, however, that when this experiment is carried out with bromine and alkali according to the directions given in many laboratory manuals, a considerable portion of the product consists of ammonium chloride.

In this paper directions are given for the preparation of methylamine hydrochloride from acetamide using commercial calcium hypochlorite* and sodium hydroxide. The product obtained with these reagents is contaminated with only a small amount of ammonium

* The Mathieson Alkali Works, Niagara Falls, N. Y., manufacture calcium hypochlorite under the trade name of "H.T.H."

chloride, and this can be removed by treatment with aqueous alkali as described below.

In this experiment, acetamide is first converted into *N*-chloroacetamide, which, in the presence of alkali, eliminates hydrogen chloride and undergoes rearrangement to form methylisocyanate. Hydrolysis of the latter gives methylamine which is isolated as the hydrochloride. It should be pointed out that the elimination of hydrogen chloride from *N*-chloroacetamide in the presence of alkali, actually consists of the removal of the hydrogen as a proton to form the alkali salt of *N*-chloroacetamide; the chloride ion is apparently released from the anion of this salt. The complete transformation may be represented by the following equations.

$$2CH_3CONH_2 + Ca(OCl)_2 \longrightarrow 2CH_3CONHCl + Ca(OH)_2$$

$$2CH_3CONHCl + Ca(OH)_2 \longrightarrow (CH_3CONCl)_2Ca^{++} + 2H_2O$$

$$(CH_3CONCl)_2Ca^{++} + 2NaOH \longrightarrow 2(CH_3CONCl)^-Na^+ + Ca(OH)_2$$

$$2(CH_3CONCl)^-Na^+ \xrightarrow{\text{heat}}$$

$$2CH_3N{=}C{=}O \xleftarrow{\text{rearrangement}} 2CH_3CON + 2NaCl$$

$$2CH_3N{=}C{=}O \xrightarrow[4(NaOH)]{HOH} 2CH_3NH_2 + 2Na_2CO_3$$

$$2CH_3NH_2 + 2HCl \longrightarrow 2(CH_3NH_3)^+Cl^-$$

Preparation of Methylamine Hydrochloride.—The apparatus for this experiment should be set up before any materials are mixed.

A 500-cc. distilling flask is fitted with a two-hole stopper carrying a thermometer and an inlet tube for air. The bulb of the thermometer should dip below the surface of the liquid, and the air tube should reach almost to the bottom of the flask. The distilling flask is attached to a condenser bearing an adapter. Two 250-cc. Erlenmeyer flasks containing 35 cc. each of 6 *N* HCl are placed in series as receivers. The first is fitted with a two-hole stopper. A glass tube attached to the adapter should dip below the surface of the HCl in the first receiver. The second receiver is connected to the first by means of another glass tube leading from above the acid solution in the first receiver to below the acid in the second.

To 16.4 g. of "H.T.H." in an Erlenmeyer flask is added 50 cc. of water, and the mixture shaken until practically homogeneous. A small amount of material will remain undissolved. The solution is cooled to about 0° in an ice-bath and 10 g. of crushed ice added.

The distilling flask is disconnected, and a cold solution of 10 g. of acetamide in 20 cc. of water poured into it. With the distilling flask immersed in an ice-bath, 100 g. of crushed ice is first added to the solution, followed by the addition of the *cold* "H.T.H." solution in three or four small portions with shaking after each addition. The temperature of the mixture should not rise above 0°. More ice may be added to the reaction mixture if necessary. If the mixture should warm to more than 10° (due to insufficient cooling), it should be discarded and the experiment repeated.

The flask is allowed to remain in the ice-bath for five to ten minutes. At the expiration of this time the flask is fitted to the condenser and a solution of 24 g. of NaOH in 40 cc. of water at room temperature is added. The stopper is immediately replaced, and a current of air passed through the mixture during the remainder of the manipulations. The current of air should be sufficient to produce thorough mixing of the contents of the flask and to prevent bumping, yet not strong enough to cause much loss of the methylamine from the receivers.

By heating the flask the temperature of the mixture is raised rapidly to about 60°. Between 65° and 75° the *N*-chloroacetamide decomposes with liberation of considerable heat, which, if not controlled, is likely to cause the contents of the distilling flask to bump over into the condenser. Consequently, the temperature is increased carefully from 60° to 65° and the flame removed. From this point the temperature will increase without the application of external heat. The current of air passing through the mixture is regulated so that it is just sufficient to prevent bumping. If the temperature rises to 80° the flask is cooled in a bath of crushed ice and water. The temperature is held between 70° and 80° for five to ten minutes, or until heat is no longer spontaneously generated.

The contents of the distilling flask are then heated to boiling and distilled until 75 to 100 cc. of distillate has been collected. The contents of the two receivers are combined, placed in a large evaporating dish, and evaporated over a wire gauze until the volume of the solution is about 15 cc. The dish is then transferred to a water bath and the contents evaporated to dryness.

The solid residue consists of methylamine hydrochloride together with a small amount of ammonium chloride. This product may be crystallized directly from absolute alcohol, in which case, the yield should be about seventy per cent. of the theoretical amount. It is recommended, however, that the crude product be purified according to the following procedure. The crude product is transferred to a casserole and dissolved in 15 cc. of water. Ten cc. of 7.5 per cent. sodium hydroxide is added and the solution heated to gentle boiling over a small flame. Since methylamine is a stronger base than ammonia, the latter, which is preferentially liberated from its hydrochloride, will be driven off with only a slight loss of methylamine. The casserole is kept in constant motion and the heating continued until all the water has evaporated and dense white fumes appear. A portion of the methylamine hydrochloride will be in the fused state. The flame is removed and the mass stirred while cooling. If the residue does not completely solidify when cold it is heated further. The residue is finely pulverized, transferred to a 250-cc. Erlenmeyer flask, and refluxed a few minutes with 125 cc. of absolute alcohol. A small amount of solid (NaCl) will remain undissolved. The solution is filtered through a steam funnel into a 250-cc. Erlenmeyer flask. The latter is connected by means of a bent glass tube to a condenser and the

alcohol distilled off until crystals begin to form in the hot liquid. The solution is then allowed to cool to room temperature and is finally cooled in an ice-bath. The crystals are filtered with suction, washed with 10 cc. of absolute alcohol, and dried on a watch glass set on a hot steam coil. The yield of methylamine hydrochloride should be about fifty-five per cent. of the theoretical amount, melting at 228–230°.

The use of air in this experiment serves to agitate the mixture and prevent it from bumping. If desired, a mercury-sealed mechanical stirrer may be used for this purpose and the air omitted. In this case one receiver will be sufficient. A short-stem funnel is fitted to the adapter, the larger end of the funnel dipping about 0.5 cm. below hydrochloric acid contained in a beaker. By using a mechanical stirrer the reaction may be carried out on a larger scale with no essential modification in procedure.

A DEMONSTRATION OF THE NECESSITY FOR CARE IN SAMPLING

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PROPER sampling is often more difficult than the analysis of the sample after it is obtained. This fact is seldom appreciated by students in quantitative analysis, even though they may be given several lectures on the subject. Their failure to appreciate the necessity for care in sampling is due, in part at least, to the fact that the samples usually issued to students for analysis are practically fool-proof. They are very finely ground in order that individual samples may be taken quickly, without special precautions, from a stock sample.

During the past four years, an exercise intended to impress upon students the importance of sampling has been included in a specialized course in analysis given by this department. It has proven so simple, and so effective, that it may be of interest to other teachers in analytical courses.

All of the students in this course have completed at least three hours, and some have completed six hours, of quantitative analysis in the chemistry department. As a preliminary exercise, they are asked to standardize approximately tenth normal solutions of acid, alkali, and silver nitrate. Each student is then given a sample and asked to analyze it in triplicate with great care. He is told that this is a test of his ability to do accurate work. The nature of the sample is such that great care is necessary in sampling, but almost invariably the students treat it as though it were already finely ground and intimately mixed. Later there is consternation and dismay when they discover that duplicate titrations may differ in the ratio of 2:1, or even more.

The results obtained by the class in 1935 may be considered as typical. There were fifteen students in the course and each reported the results of three analyses. The samples were all identical and each contained chloride equivalent to 39.20 per cent. NaCl. The results of individual determinations ranged from 25.40 per cent. to 79.16 per cent. The nearest single determination was 44.79 per cent. The nearest average of three titrations was 42.40 per cent. the individual titrations being 29.66 per cent., 47.58 per cent., and 49.97 per cent.

One student weighed out four portions with the intention of reporting the three in closest agreement. When he obtained values of 55.45 per cent., 45.74 per cent., 55.79 per cent., and 56.20 per cent., he accused the instructor of not mixing the sample. He then weighed out three more portions after shaking the remainder of his sample vigorously. These gave values of 25.40 per cent., 47.10 per cent., and 60.92 per cent.

This particular student then weighed and titrated all of the remainder of his sample, and by adding up the chloride found in each titration, and the weights of the various portions, he calculated the sodium chloride in the entire sample issued to him. This result was 39.00 per cent.

When it was finally explained to the class that the samples could not be adequately mixed without additional grinding, this student asked for another sample. He ground it carefully in a mortar before weighing out portions for titration. The duplicates checked closely, and gave an average value of 39.16 per cent. of NaCl.

We do not often have a student as persistent as this one, but each year the results of the class as a whole are similar to those just described, and we feel that the necessity for care in sampling is clearly demonstrated.

The actual preparation of the samples is not difficult. The materials used in this particular case were KCl which had been screened to pass an eight-mesh but not a twenty-mesh sieve, and ordinary granulated sugar. The samples issued to students contained 5.000 grams of each of these substances. Various other combinations have been used, and many are possible. The only requirement is that the active and inert ingredients be of different particle size, those of one component being relatively large. The samples must be prepared individually, but if five-gram portions of high grade chemicals are weighed out with an accuracy of two or three milligrams, the true composition of the mixture is known with greater accuracy than that of many of the samples used in analytical courses. The actual weighing can often be turned over to an assistant who need not even know the nature of the substances weighed, and consequently could not know the composition when calculated in terms of some other salt.

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KEEPING UP WITH CHEMISTRY

Coal tar as a chemical raw material. D. W. JAYNE. *Chem. Industries*, **40**, 587–91 (June, 1937).—Coal tar is the condensable oil product distilled from coal. It consists principally of various aromatic hydrocarbons. The quantity relationship of these hydrocarbons depends on the coal used, the temperature-time factor during distillation of the coal, and the type of distillation apparatus used.

Distillation may be carried out in retorts in the gas manufacturing process, or in "by-product" ovens where the coke residue is the major objective. The term "coal tar" comprises both "gas-works" tar and "coke-oven" tar.

Coal tar first became a commodity in England early in the nineteenth century when plants began to be erected to make illuminating gas. The tar was a "nuisance" by-product. Its early uses were principally for coating pipes and metal surfaces. Prior to the middle of the nineteenth century it was found that the oils distilled from coal tar had a preservative effect on wood, and its use on piling, telegraph poles, and railway ties increased rapidly here and in Europe. Pitch, resulting from the removal of the oils from tar by distillation, was used (mixed with gravel) for sidewalks and later for water-proofing structures, and in conjunction with felt paper saturated with tar, "built-up" roofs came into vogue, which were called "slag" roofs because slag was applied on the surface.

None of these uses gave to coal tar the rôle of a chemical raw material. The composition of coal tar had been, however, a subject of chemical research in Europe since the middle of the nineteenth century, and through this study the development of synthetic dyes was started. The chemical entities derived from coal tar were used as the materials from which were made the "intermediates" for the subsequent constituents for the dye-stuff industry and coal tar became a chemical raw material in England and Germany.

The separate constituents recovered from the distillates from coal tar are a small percentage of the total tar, so that creosote oil for wood preservation and tar and pitch for road treatment and waterproofing uses, continued to be important. Also the hard pitch residue resulting from the distillation became an important commodity in the production of coal briquets. Toward the end of the nineteenth century important synthetic drugs, medicinal chemicals, perfumes, and photographic developers were also produced from intermediates based on the coal-tar hydrocarbons. Early in the twentieth century high explosives based on hydrocarbons from coal tar or of the same series as those contained in coal tar were developed. These European developments were but slightly reflected in the United States.

Until the Great War, uses of tar in the United States were practically confined to the production of roofing and waterproofing products, timer preservatives (including wood blocks for paving), paints, and the binding of stone roads (tar macadam). Some was burned in open hearth steel furnaces. Naphthalene and tar acids (phenols and cresols) were recovered in a small way, the former to make " moth balls " and the latter for pharmaceutical and disinfectant products.

Coal tar thus did not become a chemical raw material in the United States until the war caused the development here of industries making dyes and other synthetic products derived from the products of coal tar distillation. Even at present the percentage of the total coal tar production of the United States, which provides materials for the synthetic chemical industry, is small. Nevertheless the distillation of coal tar is, and properly should be, classed as a chemical industry as its progress has depended on the application of chemical engineering to the distillation and collateral steps involved in making marketable products from it. A. T. B.

Tear gases. R. W. SADTLER. *Chem. Industries*, **40**, 584–6 (June, 1937).—Tear gases or lacrimators are chemical compounds or mixtures which affect the eyes, causing copious and involuntary weeping. They produce an intolerable atmosphere in concentrations many times more dilute than required for the most effective toxic gases. They range from what might be considered annoying to those which cause such a flow of tears that the victim is completely blinded for the time being. Most are not toxic in the concentrations usually employed, but in higher concentrations some are highly toxic, and many irritate the skin.

All known tear gases are halogen compounds. Aromatic halogen compounds in which the halogen is in the side chain are, as a class, lacrimators; but all lacrimators do not belong to this class of compounds.

Bromacetone, bromomethylethylketone, benzylbromide, ethyliodoacetate, and brombenzylcyanide were the chief tear gases used during the World War. Since then, however, the army has concentrated its attention and plans on the four following compounds or mixtures thereof: chlorpicrin, chloracetophenone, "tear gas solution" (a mixture of chloracetophenone, chlorpicrin, and chloroform) and brombenzylcyanide.

This article also gives the method used by the army for the preparation of each of the tear gases last mentioned and lists many of their properties such as persistency, tactical classification, physiological classification, odor in air, M.P., H.P., action on metals, etc. A. T. B.

Electrochemical production of sodium chlorate. P. H. GROGGINS AND ASSOCIATES. *Chem. & Met. Eng.*, **44**, 302–7. (June, 1937).—Weeds levy an annual toll of about $3,000,000,000 on American agriculture. Hundreds of chemical compounds have been suggested and tried to eliminate them. By and large the chlorates have the fewest drawbacks, and field investigations indicate sodium chlorate is probably the most general herbicide.

Congress directed the Department of Agriculture to investigate the manufacture and use of sodium chlorate, and the results are presented in this paper. A thorough study was made of the electrochemical process, and it was concluded $0.049 per pound was a reasonable cost of production. The enterprise is seasonal and is confronted with both industrial and economic hazards.

The farmer must pay from nine to ten cents per pound for chlorate, and using one hundred sixty-five pounds to the acre the expense would be $14.85 to $16.50 per acre. This would be considered too high a cost by most farmers. J. W. H.

Oil refinery hydrogen sulphide found to be economical sulphuric acid source. F. L. CRAISE AND E. S. BROUN. *Chem. & Met. Eng.*, **44**, 376–9 (July, 1937).—Converting an industrial waste product into a highly profitable by-product was an opportunity which presented itself to the El Segundo refinery of the Standard Oil Company of California. This plant uses in its cracking plant a crude oil running from 0.5 to 2.5 per cent. sulfur. The gases from the cracking plant run four to six per cent. hydrogen sulfide by volume. Suitable equipment has been designed for removing, purifying, transporting, measuring, and analyzing this hydrogen sulfide as well as converting it later into sulfuric acid. J. W. H.

Toxicity to insects and mammals of foods containing selenium. S. F. TRELEASE AND H. M. TRELEASE. *Am. J. Botany*, **24**, 448–51 (July, 1937).—Bruchids and seed-chalcids consumed seeds of

Astragalus bisulcatus containing 1475 parts per million of selenium and completed their life cycle. These insects thrived on a diet containing about seventy times the concentration of Se which is known to be lethal within a few weeks to rats, cattle, pigs, sheep, and horses.

When rats were fed on a diet containing only sixty-five parts per million of Se derived from ground pods and seeds of *Astragalus racemosus*, they were killed within four to eleven days.

The *Astragalus bisulcatus* plants, though growing in soil containing only about from two to four parts per million of Se, were able to accumulate 1475 parts per million. E. D. W.

In Sinbad's cargo. ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **127**, 3–4 (Aug., 1937).—Among the important achievements at the beginning of the twentieth century was the improvement of one of the world's oldest materials—shellac. A decade later, synthetic resins began to take its place, but at the present time interest has been revived in this age-old material. Many of the properties of shellac have not yet been duplicated. The thermoplastic properties of shellac were utilized even in prehistoric times for the manufacture of casts and molded articles. No plastic has yet been found that is satisfactory for phonograph records; shellac reproduces with amazing fidelity every detail of the sound track of the master record. All high quality records for transcription and instruction in foreign languages are still made from shellac. Because of its excellent dielectric properties, it is held in high favor in the electrical insulation industry. It is also used in the manufacture of adhesives, sealing wax, and special inks. Modern methods with technical control are producing a more uniform lac from which the shellac is made so that it may meet the serious competition of the synthetic resins and the ever-changing demands of the consumer. Probably more has been learned about shellac in the last five years than in the preceding 1500 years. The Indian Lac Research Institute has made a general study of the physical properties of various modifications of shellac plastics. They have incorporated phenol-formaldehyde resin in shellac molding powders and report that these compositions can be ejected from the mold at the temperature at which they have been cured. Shellac importers are relying upon shellac to hold its own in established fields because of its unusual combination of qualities. G. O.

SCIENTIFIC REVIEWS AND BIBLIOGRAPHIES; TABULATIONS OF SCIENTIFIC DATA

Localization of ascorbic acid in the cowpea plant at different periods of development. M. E. REID. *Am. J. Botany*, **24**, 445–7 (July, 1937).—The organs with the highest ascorbic acid (vitamin C) content in the cowpea are those which have the greatest cellular activity, *viz.*, the mesophyll of the leaves, the young ovary, the embryonic and elongating regions of root, and stem, and the leaf and blossom buds. A survey of the changes in ascorbic acid content which the tissues and organs undergo during development is also given. E. D. W.

Recent history of the sterol group.—II. C. DOREE. *Sch. Sci. Rev.*, **18**, 490–9 (June, 1937).—A discussion of the chemistry of ergosterol and its irradiation products, the sex hormones, the cardiac aglucones, the toad poisons, and the cancer-producing hydrocarbons. Thirty-two references. S. W.

Precipitation of metallic sulphides. A. J. MEE. *Sch. Sci. Rev.*, **18**, 500–12 (June, 1937).—Calculations from solubility data collected by Kolthoff (*J. Phys. Chem.* (1930)) indicate that the only sulfides which should not be precipitated from acid solutions in the usual concentrations employed, are ferrous sulfide, and the green form of manganous sulfide. The precipitation of zinc, nickel, and cobalt sulfide from acid solution has actually been observed, but only after standing several months. The difference between the results predicted by the concept and those observed by experiment may be largely explained by the difficulties involved in the determination of the solubility product. Solubility product determinations are usually carried out on a sample which has been dried and stored. It must be recognized that the solubility of a difficultly soluble salt varies according to its age; and it follows that conclusions based on solubilities thus determined are not necessarily applicable when precipitation is being considered. The nature of precipitated zinc, mercuric, cadmium, and manganous sulfides has been examined, and in each case change of crystalline form with age and method of precipitation has been found. Such changes are bound to affect the solubility product. Middleton and Ward (1935) describe experiments on the composition and properties of precipitated nickel and cobalt sulfides. The precipitates are of different composition according to whether oxygen is present or not during the precipitation.

Errors are frequently caused by the "carrying down" of one metallic sulfide by another, and very often the precipitation is at variance with the concept of solubility product. The most obvious explanation of the phenomenon would be to ascribe it to the formation of loose compounds, or mixed crystals. Such mixed crystals occur in nature as minerals (CoAsS, $CuFeS_2$, etc.). The phenomenon has also been attributed to adsorption.

It is usually assumed that the precipitation of the sulfides is due to the S^{--} ions formed in the second dissociation of H_2S. It was first pointed out by G. M. Smith (1922) that the precipitating agent is more likely to be the HS^- ions. The number of S^{--} ions in an acid solution of H_2S is of the order of 10^{-22}. This explanation may account for the marked adsorption of hydrogen sulfide by sulfides, just as many hydroxides are considered to consist of the oxide plus varying amounts of adsorbed water. It has also been maintained that the precipitation of sulfide is not an ionic process at all. It may be concluded, however, that the ionic theory, coupled with the law of mass action, provides an adequate explanation of the precipitation of metallic sulfides if applied under the actual conditions of the precipitation. The article contains ten references. S. W.

HISTORICAL AND BIOGRAPHICAL

The Halle Academy. ANON. *Nature*, **140**, 179–80 (July 31, 1937).—"The Kaiserlich Deutsche Akademie der Naturforscher at Halle has recently celebrated the two hundred and fiftieth anniversary of the granting of its charter. . . It is one of the oldest of scientific societies." Its journal *Nova Acta Leopoldina* was started in 1670. Representatives from German and foreign universities, academies, and societies were welcomed by its president, Professor E. Abderhalden. M. E. W.

Ammonolatry: the life element. Henry E. Armstrong. *Nature*, **140**, 134–8 (July 24, 1937).—During the last weeks of his life, Professor Armstrong was deeply engrossed in two books: E. C. Franklin's "Nitrogen System of Compounds" and N. V. Sidgwick's "Organic Chemistry of Nitrogen." In 1872–3 George Gore prepared liquid ammonia by heating ammoniated calcium chloride, and tested the solubility in it of more than five hundred substances. In 1896 H. P. Cady suggested that liquid ammonia would probably be found to resemble water in its physical and chemical properties. From this suggestion, said Dr. Franklin, "has followed all the work in this country on liquid ammonia." Professor Armstrong said that Franklin's "work on ammonia already of no slight value, may some day rank high when the great problem of electrolytic conductivity is discussed with knowledge and without prejudice: as yet, it never has been. . . ." Professor Armstrong regretted that Franklin's original papers were not "largely reproduced in readable form" in his recent book, and added, "If his friends were to provide a reprint, it would be a pious act and a great boon to students." M. E. W.

Death of Professor H. E. Armstrong. W. P. W. *Nature*, **140**, 140–2 (July 24, 1937).—Professor Henry Edward Armstrong died on July 13, 1937 in his ninetieth year. He studied under Hofmann, Tyndall, Huxley, Ramsay, Frankland, and Kolbe. For many years he taught chemistry at St. Bartholomew's Hospital Medical School, London, and later at the City and Guilds College, South Kensington. He carried out an elaborate research on the bromination, nitration, and sulfonation of naphthalene and of its halogen and hydroxy derivatives, and prepared and

identified all ten of the dichlor naphthalenes and all fourteen of the corresponding trichlor derivatives. With his collaborators, Armstrong helped to solve the problem of the constitution of camphor. He denounced the theory of electrolytic dissociation in solution and maintained "that solution is in effect a manifestation of chemical activity, the production of an electrolyte in aqueous solution being dependent on the combination of solvent and solute." With his son, E. F. Armstrong, he made a protracted study of enzymes. M. E. W.

Science news a century ago. Hare and the oxy-hydrogen blowpipe. ANON. *Nature*, **140**, 291 (Aug. 14, 1937).—On August 14, 1837 Professor Robert Hare of Philadelphia announced in a letter to John Dalton that he had succeeded in fusing with his improved oxy-hydrogen blowpipe more than three-fourths of a pound of platinum. He asked Dalton to communicate this fact to the British Association for the Advancement of Science, and added, "How much would it gratify me, could I exhibit to them, and their enlightened visitors, that splendid concentration of heat and light which I have lately employed, by which a metal infusible in the air-furnace or forge is made as fluid as mercury, so as to be blown off in globules." M. E. W.

Use of the name "racemic acid." A. FINDLAY. *Nature*, **140**, 22–3 (July 3, 1937).—There has been some confusion in chemical literature as to whether Gay-Lussac, Berzelius, or Gmelin originated the name *racemic acid*. This term first appeared in Gay-Lussac's "Cours de chimie. . . " published in Paris in 1828 by Pichon et Didier. This volume was published, against Gay-Lussac's wishes, from shorthand notes of his lectures, and the word *racémique* was incorrectly printed *racenique* or *racénique*. The French translation of Berzelius' original paper on the composition of tartaric and racemic acids and the "Chemistry of Organic Bodies. Vegetables" by Thomas Thomson both mention that the name *racemic acid* is due to Gay-Lussac. He, however, applied this term only to the specific isomer of tartaric acid. Pasteur extended the application of the term *racemic* to include " the optically inactive, resolvable isomer" of a substance. M. E. W.

Professor A. G. Perkin, 1861–1937. E. J. CROSS AND F. M. ROWE. *Nature*, **140**, 13–4 (July 3, 1937).—Professor A. G. Perkin, together with his two brothers, followed in the footsteps of their distinguished father, Sir William Perkin. He studied under Frankland, Guthrie, and E. J. Mills, and worked with J. J. Hummel at Yorkshire College, Leeds, on new compounds derived from the coloring matters of brazilwood and logwood. From 1882 to 1892 he served as chemist, and part of the time as manager, of an alizarin factory in Manchester. With W. H. Perkin, Jr., he studied the derivatives of anthraquinone and the coloring matter of the Indian dyestuff *kamala*. In 1892 he joined the dyeing department of Yorkshire College, where he devoted more than twenty years to research on the isolation of the coloring principles from natural products and the study of their constitutions. In later years he investigated the anthraquinone derivatives. In 1916 he became professor of color chemistry and dyeing at the University of Leeds, where he continued his researches until the last year of his life. M. E. W.

GENERAL

Mines and minerals of Connecticut. S. A. MONTAGUE. *Rept. New Eng. Assoc. Chem. Teachers*, **38**, 109–16 (Mar., 1937). —Nature was prodigal in the number and variety of minerals which she stored in this state, as the ores of eleven different metals have at one time or another been mined in the state; minerals containing twenty-six other metals are known to occur here, and a wide variety of non-metallic minerals found in the state brings the total number of minerals found in the state to about one hundred fifty. But nature was lavish only in variety and very seldom in quantity or richness of the deposits. The metals which have actually been mined in Connecticut include arsenic, barium, bismuth, cobalt, copper, iron, lead, nickel, silver, tungsten, and zinc. The following metals have been found in this state in small amounts or in deposits which were too inaccessible to be mined profitably: aluminum, beryllium, boron, cadmium, calcium, caesium, cerium, chromium, columbium, gold, hafnium, lanthanum, lithium, magnesium, manganese, molybdenum, potassium, radium, rubidium, sodium, thorium, tin, titanium, uranium, yttrium, zirconium.

The beginnings of the mineral industry go back to early colonial times and continued until as recently as 1920 when the last mining operations ceased because of inability to compete with richer deposits elsewhere. Copper was the first metal mined; the deposit of chalcotite at Granby yielded copper as early as 1709. The deposit of siderite at Roxbury yielded iron for Revolutionary cannon and was worked for over two hundred years, operations ceasing in 1920. At present mica and feldspar are mined in Middlesex County in sufficient quantity so that today Connecticut ranks second among the states in the production of mica. W. O. B.

The natural philosophy of paintings. F. I. G. RAWLINS. *Nature*, **140**, 219–20 (Aug. 7, 1937).—The scientist can aid art curators by his knowledge of materials and by improving the environment in which paintings are kept. "The essential characteristic of a painting. . . is its stratified structure. In order, there are (*a*) the support, or carrier. . . (*b*) the ground, (*c*) the paint film, and (*d*) the surface or varnish film. . . .All these layers react to some extent upon one another. . . ." Physical methods are often used, or a microscopic amount of material removed from under the frame is subjected to chemical or spectroscopic analysis. A micro-borer is sometimes used for taking samples through all the different layers. Unless the film of paint is too thin, X-ray examination is helpful, and "areas containing much lead or mercury, in the neighborhood of compounds like the lakes, composed of elements of low atomic weight, make excellent subjects . . . . A previous version of a composition may be discovered or . . . the work of two artists can be distinguished." For the benefit of art students, it would be desirable to remove the glass from the frames. However, if moisture condenses as a film over the varnish, and dust particles settle on this film, it is very difficult to remove the dirty layer without damaging the varnish. This is a strong argument for the air-conditioning of museums. "Perhaps the greatest need of all. . .is a closer understanding between the outlook of the student of art history and that of the scientific investigator. . . .Some of the great masters were intellectuals of a high order. . . . To know them better is to broaden our concept of natural philosophy." M. E W.

Coal and other minerals in Rhode Island. J. S. BEACH. *Rept. New Eng. Assoc. Chem. Teachers*, **38**, 137–43 (May, 1937). —Few people realize that there is anthracite coal in the state of Rhode Island, yet more than one-third of the state is underlaid by a series of anthracite coal beds, varying from a few inches to nearly fifty feet in thickness. These deposits were laid down during the Pennsylvanian Age at approximately the same time as the better-known coal seams in Pennsylvania. Rhode Island coal has passed beyond the anthracite stage and more nearly approaches the graphite stage. Indeed, one of the mines formerly operated in Cranston was run primarily to secure graphite for lubricants and furnace linings. Rhode Island coal burns with a fierce heat once it is ignited properly but it is more difficult to ignite than Pennsylvania coal which does not require as high temperatures. It has such a high percentage of ash that it clinkers easily and tends to ruin ordinary grates. To eliminate many objectionable features of the Rhode Island coal a flotation process was instituted at the Cranston mine whereby the coal was crushed into dust and oil was added. The coal dust clung to the oil, thereby being separated from the silica and other impurities. The coal dust with the oil binder was then pressed into briquets. These briquets gave a good heat and left little ash, but housewives objected to the smoke caused by the oil binder. The Cranston coal in heat value compared with the average Pennsylvania coal approximately as ninety-six to one hundred twenty-nine. Many attempts have been made to mine and market Rhode Island coal since Revolutionary times with failure after failure to place the product successfully on the market. One mine in Cranston is still in operation. Other minerals in the state include iron ore near Woonsocket and limestone which is quarried at Berkeley. Talc and steatite are also found in considerable amounts. The Indians formerly quarried the steatite and formed it into pots and bowls. W. O. B.

RECENT BOOKS

AMBIX THE JOURNAL OF THE SOCIETY FOR THE STUDY OF ALCHEMY AND EARLY CHEMISTRY. Vol. 1, No. 1, London, May, 1937. 18.2 × 24.5 cms. 92 pp. Illustrated. Price for one year (four issues) one pound four shillings; gratis to members of the Society (annual dues one pound one shilling).

The Society for the Study of Alchemy and Early Chemistry was organized during 1936. Its officers are President, Sir Robert Mond, and Members of the Council, Prof. K. C. Bailey, K. de B. Codrington, L. F. Gilbert, Prof. S. R. K. Glanville, Sir Richard A. Gregory, G. Heym (Hon. Foreign Sec.), Dr. E. J. Holmyard, Dr. L. W. G. Malcolm, Dr. Stephen Miall, Dr. D. McKie (Hon. Treasurer), Prof. J. R. Partington (Chairman), and Dr. F. Sherwood Taylor (Hon. Sec. and Editor, address 8 Bream's Buildings, Chancery Lane, London, E. C. 4.). *Ambix* is the only journal in the world devoted wholly to the history of chemistry, though not to the whole of that history. Students of the history of chemistry will be interested in everything which it contains, and no library for the use of students of chemistry or of the history of chemistry can afford to be without it. The first number sets a high standard of scholarship. We propose therefore to review *Ambix* as if it were a book and to give a brief, but fairly detailed survey of its contents. The Greek word, αμβιξ means cup or the cap of a still, stillhead, whence the Arabic al-anbīq, alembic.

Ambix, Volume 1, Number 1, commences with a two-page article by Sir Robert Mond on "The Study of Alchemy" which describes the purposes of the new Society. Pages 3–20 are devoted to an article by Partington on "Albertus Magnus and Alchemy" in which the known facts concerning his life are recounted and the chemical content of his genuine works indicated. "The parts of Albert's undoubtedly genuine writings which are of chemical interest are mostly contained in his commentaries on physical books of Aristotle (which have many incidental references to alchemy) and in his genuine *Mineralium libri V* (or, as it is called in some editions, *De Mineralibus et rebus metallicis*) which (if it is the *De lapidibus* frequently mentioned in the *Meteorum*) is one of the early works, perhaps written in Paris in 1240–45. In these Aristotle is his chief authority. . . . Albert's information on alchemy, however, is largely taken from the *De anima* of Ψ-Avicenna and some other Arabic works, as well as from personal observations of the work of alchemists, probably in Cologne and Paris." An act of the Franciscans forbidding the study of alchemy and a decree of Pope John XXII against false coiners are quoted. The alchemical works which are attributed to Albert, probably falsely, are also listed and described.

"Methods of Research in the History of Chemistry," by Julius Ruska, pages 21–29, describes the part which the critical methods of the careful historian have played, and not played, in the work of writers on the history of chemistry. "In the time of Borrichius it was common knowledge and could not be doubted that the *prima Artis magnae semina* were inherited from Adam by his more pious and more secretive descendants, that Tubal Cain (perhaps *proprio impetu*) and Bezaleel (but *ipso deo inspirante*) pursued the art of Alchemy, that Hermes Trismegistus was identified with the Biblical Canaan, that his alchemistic wisdom was deposited in the *Tabula Smaragdina*, and that all the knowledge of the later alchemists is ultimately derived from these old and genuine sources." To show the effect of critical research Professor Ruska describes the way in which Morienus has been handled by Borrichius, Schmieder, Gmelin, Kopp ("the last representative of that learned method which, with the most meticulous accuracy and infinite diligence, set down what was supposed to be known, in the XVIIth and XVIIIth centuries, about the Alchemists and their writings, in order to advocate one or the other of the opinion as the more possible"), Berthelot (with whom "a new age in the History of Chemistry began"), von Lippmann, and Reitzenstein, and finally points out that the whole question of the origin and authenticity of the Morienus stories remains unsettled. He concludes the article with a brief mention of the new understanding of al-Razi which recent research has produced. "The inevitable consequence of critical philological work is the destruction of illusions, but there remains no other way of clearing the undergrowth of legends and of approaching historical truth."

In his valuable survey of "The Origins of Greek Alchemy," pages 30–47, F. Sherwood Taylor says—"There seems little reason to believe that the Alchemy of Hellenistic Egypt had any contact with that of China. There is some slight likeness of materials: but to the early Alchemy of the West are unknown the two central notions of Chinese Alchemy, namely, the prolongation of life and the Philosopher's Stone, a minute portion of which would transmute a large quantity of base metal. Both these notions appear in the West for the first time in the alchemical texts of the Arabs." The article concludes as follows—"All of the important early texts have now been considered, and it is clear that no one of these can be regarded as the original source of the alchemical tradition. The following groups of texts appear to represent different schools of alchemical thought, and there is no reason to suppose that any one of them is earlier than the others.

The Democritan Treatise. (Practical colouring of metals.)
The lost work of Maria. (Operations involving elaborate apparatus.)
The works attributed to Kleopatra. (Mystical.)
The works attributed to Ostanes. (Mystical and practical.)
The fragments of Hermes. (Mystical and practical.)
The Egg-symbolists. (Symbolic.)

"It must be concluded that, at the date when these earliest treatises were written, Alchemy was already a well-developed system with several schools of thought. There is, however, no direct evidence in the Greek alchemical texts of any remote antiquity for the origin of Alchemy. The definite assertion of the texts, their place of origin, and the character of their mythology and symbolism indicate that their immediate source was Egyptian; but the acceptance of the assertion that the texts are based on secret knowledge immemorially in the possession of the Egyptian priesthood must be matter for individual judgment. If we accord even a tentative adherence to such a theory, we may be comforted by the certainty that the evidence for any other origin of Alchemy is even more slender." In the last sentence of the just-quoted passage, the word, Greek, ought to be inserted before the word, Alchemy.

"An Introduction to the Bibliography of Alchemy. Part I," pages 48–60, by Gerard Heym lists (1) Bibliographies, (1a) Bibliographies that contain titles of Alchemical books, (1b) Catalogues, (2) Collections of Alchemical Texts, (3) Alchemical Lexicons, and (4) Tables of Alchemical Symbols.

A "Report of Discussion upon Chemical and Alchemical Symbolism," consists of five short papers. Partington's paper on "The Origins of the Planetary Symbols for the Metals," pages 61–4, contains a table which summarizes the different associations of the planets and metals among different ancient peoples and writers. F. Sherwood Taylor has a short article on "Symbols in Greek Alchemical Writings," pages 64–7. The article on "The Macrocosm and the Microcosm in Mediaeval Alchemy," pages 67–9, by A. F. Titley, concludes that " in attempting to interpret mediaeval alchemical symbolism, due attention must be paid to the general philosophic background and the consequent absorption with relating Alchemy to a cosmic scheme." Gerard Heym's article, "Some Alchemical Picture Books," develops another aspect of the mystical side of alchemy, and concludes—"The symbolic pictures in the two Alchemical books by Stolcius probably represent experiences with which the

intelligent student could identify himself, and it is this extension of the self which may be the key to the real understanding of symbolic Alchemy." Douglas McKie, "Some Early Chemical Symbols," pages 75–7, discusses briefly the symbols, often designed to exhibit chemical relationships, which were used by the chemists of the seventeenth and eighteenth centuries.

A review by Gerard Heym of the *Aurea Catena Homeri* (Golden Chain of Homer), pages 78–83, is typical of the sort of thing which will do much to advance our understanding of European alchemy, particularly of its digressions, of its intellectual follies and abberations. Heym has studied the book carefully and now makes clear the ideas which were actuating its author.

Several book reviews, pages 84–7, are followed by "The Visions of Zosimos," pages 88–92, translated from the Greek by F. Sherwood Taylor. "The Visions stand quite apart from his other writing, and indeed from all other Greek Alchemy, which contains nothing else of this elaborately allegorical character. They have indeed much of the character of actual dreams, which may indeed have afforded a basis, at least, for these writings."

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MAN IN A CHEMICAL WORLD, The Service of Chemical Industry. *A. Cressy Morrison.* Charles Scribner's Sons, New York City, Charles Scribner's Sons Ltd., London, 1937. xi + 292 pp. 4 figs. $3.00.

So comprehensive is the field covered by this very readable book and so simple is it in its style, that it can be recommended to the boy and girl in high school, and yet it contains such a wealth of facts concerning modern life that every man and woman should be urged to read it also. The well-read chemist will find nothing very new within its pages. However, he will find an interesting review of the achievements of his science and of the service it has been to mankind in raising the standard of living, not only materially but physically and culturally as well.

The author has pointed out that the chemist constantly improves on nature; that his discoveries are the result of the fact that nature has not given man what he found he needed or desired; but he also points out the marvels of nature, for instance, in carrying out from apparently identical starting materials, chemical reactions which produce from soil of one form, a cherry on a tree, a cantaloupe on a vine, a potato underground.

That no phase of his life is left unimproved by chemistry will be evident to the layman as he reads of the uses of air and water, and salt and sulfur, petroleum, natural gas and chromium salts; of the manufacture of rayon and wool-like fibers, of dyes; of sterilizing materials for wounds, bathing pools and dairies; of medicines, anesthetics and hypnotics; of insecticides for gardens, farms, and forests; of the development of rubber manufacture, of the many uses of rubber and the very great part it played in the development of the automobile; of metals useful and decorative and alloys for spark plugs and exhaust valves, for containers that must stand very high pressure and for airplanes, each alloy produced as a result of research in answer to a specific need; of anti-fouling paints for boats, quick-drying lacquers, and very durable enamels; of the part chemistry has played in radio, telephony, telegraphy, and television; of papers glossy and dull, parchment papers, and safety checks; of photography and its applications, for health, records, and pleasure; of special glasses for radio tubes, X-ray apparatus, home building, cooking utensils, and porcelain bathtubs; of leather substitutes, water softeners, dry ice, perfumes, and synthetic gems; helium and Zeppelins, argon electric-light bulbs and neon lights; of oils produced for certain machines and perfections of efficient machines to use heavy oils; of explosives and new types of soaps, camphor, poison- and tear-gases, fire extinguishers, non-inflammable dry cleaning materials, foodstuffs, and vitamins! And many more items besides.

Throughout the book the author points out the interrelation of materials and industries; that because of chemical discoveries and industries developed through chemical research, there has been more work and lighter work with more leisure, with the means to enjoy leisure and culture, also as a result of chemistry.

With the help of fine charts he calls attention to the increase in products available to consumers, at cost so decreased as to be startling, with constantly increasing quality. The chart concerning automobile tires will pleasantly shock almost any owner of a car.

The book covers even very recent developments of the chemical industry.

GLENOLA B. ROSE

PENNS GROVE
NEW JERSEY

COLLISIONS OF THE SECOND KIND: THEIR RÔLE IN PHYSICS AND CHEMISTRY. *E. J. B. Willey,* Davy-Faraday Laboratory of the Royal Institution. Edward Arnold and Company, London, 1937. viii + 150 pp. 26 figs. 13.5 × 22 cm. $3.60.

Klein and Rosseland (1921) first pointed out "that if fast electrons could collide with unexcited atoms and produce excited atoms and slow electrons, then the reverse process must occur, namely that excited atoms may collide with slow electrons and produce unexcited atoms and fast electrons. The process must, of course, be unaccompanied by radiation. Such a process has been called *a collision of the second kind.*" (Mitchell and Zemansky, "Resonance Radiation and Excited Atoms," page 57.) This idea has been extended to include under the same designation any collision in which electronic energy is transferred to an electron, atom, or molecule without a simultaneous emission of radiation.

The small volume under review deals with a vast group of phenomena in which such collisions are of fundamental importance. The first chapter gives the Klein and Rosseland derivation for the probability of a collision of the second kind in a mixture of electrons and atoms, in which a Maxwellian distribution of velocities has been attained for both species of particles. The titles of the other chapters are as follows: Excitation of Spectra; Ionization by Electron Transfer; Collisions of the Second Kind at Gas-Solid Interfaces; The Quenching of Resonance Radiation; and Chemical Reactions Involving Collisions of the Second Kind. A bibliography containing five hundred thirty references completes the volume. The first five chapters thus cover essentially the same topics as those dealt with by Mitchell and Zemansky, but in a much less comprehensive manner. The last chapter is of special interest to chemists, as indicated by the following subheadings: The Sensitized Interaction of Hydrogen and Carbon Monoxide; The Synthesis and Decomposition of Ozone; The Sensitized Photographic Plate; Mitogenetic Radiation; The Photosensitized Decomposition of Nitrogen Trichloride; The Interaction of Hydrogen and Oxygen; The Thermal Decomposition of Nitrous Oxide; The Deactivation of Acoustically Excited Molecules; Collision Phenomena and Radiation in Explosions; Collisions of the Second Kind in Liquid Media.

In the opinion of the reviewer the presentation could have been much improved by avoiding the use of extremely long sentences. These often make it difficult to follow the author's ideas.

SAUL DUSHMAN

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MODERN EVERYDAY CHEMISTRY. *Ralph E. Horton,* Seward Park High School, New York City. D. C. Heath & Co., New York City, 1937. viii + 451 pp. 175 figs. 15 × 21 cm. $1.68.

This textbook in chemistry is prepared for "a much larger group of young people who do not desire, or who are unable, to go beyond the secondary school." The author considers it sufficient if they are "intelligent *consumers* of technical services and goods." However, this laudable end is determined mainly by the instructor in charge and can be accomplished with the majority of pupils, irrespective of the textbook used.

The first stated purpose in the preparation of the book is "to lead to an understanding of the changing world in so far as chemical principles may help to interpret it." The preface further admits that "principles of biology and physics have been explained wherever the inquiry seemed to demand."

The second purpose is "to seek to develop scientific attitudes and habits of using scientific methods *by practice*." This idea is the foremost one in any line of education, according to John Dewey, so the author is in good company. The statement of this purpose could be strengthened by omitting the first infinitive.

The subject matter of this book is divided into five so-called units of the Morrison type. The first two are labeled "Oxidation" and "Reduction." The third has the title, "Fuels and Energy" but it consists of a description of fuels only. The fact that a fuel serves to furnish energy is given no consideration, and no comparison of the energy content of different fuels is given.

Everything about acids, bases, and salts and their ionization is included in the division called, "Water and Its Relation to Chemical Change." Finally, all other subject matter is placed under the all-inclusive title, "Chemistry and Human Affairs." The value of such large units is questionable, for they really are not unified in organization. For example, only one of the five chapters of the unit, Reduction, bears directly on the subject. A chapter on iron and steel is brought forward as another chapter which is mostly descriptive of manufacturing processes and uses. The main subject of metallurgy and reduction of ores is given scant treatment in the last unit. The units on oxidation and reduction occupy a space of one hundred fifty-four pages, yet they are defined as "combining with oxygen" and "removal of oxygen." The discussion of the structure of atoms is given in these units so it was easily possible to have given their complete meaning in the losing and gaining electrons.

The best features of the book are the discussions of method which appear consistently throughout the book. The discursive style of explanation with its personal appeal will be appreciated by the pupils for whom this book was intended. The difficulties of the organization will not attract their attention to any great extent. In keeping with this type of book numerous suggestions are made for teacher or pupil demonstration experiments. There is real value in this close association of experiment and explanation.

The chapters are closed by summaries of the incomplete sentence type. These summaries are labeled as principles, yet many rather trivial facts appear with the principles. A list of problems for investigation follows. They are well chosen. The chapter ends with a list of questions which are really exercises; only a few are real questions.

Twenty-nine books to read are listed at the close of the several units. Nine science journals are listed just before the appendix, which consists of only two pages of the elements with their common properties.

Admittedly, the book does not attempt to meet the requirements of the College Entrance Board. While the last unit is intended to be used as optional ground, it does not furnish enough practice in fundamentals for the student who expects to continue his study of chemistry in college. We would like to have a basic fundamental course within the reach of all, with additional more advanced work for the more capable pupil. One is impressed with the fact that so much of value has been put in a limited number of pages.

HERBERT R. SMITH

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LECTURE EXPERIMENTS IN CHEMISTRY. *G. Fowles*, M.Sc., A.I.C., F.C.S., Latymer Upper School, London. P. Blakiston's Son & Co., Inc., Philadelphia, 1937. xvi + 564 pp. 150 figs. 13 × 21 cm. $5.00.

The author successfully attempted to furnish the secondary and college teacher of chemistry with a wealth of lecture experiments. Five hundred forty-seven independent experiments, mostly qualitative, but several quantitative, have been selected from the literature. These experiments date from the beautiful demonstrations of Bunsen and Ramsay to the present day. The author has given credit for the ideas whenever he could discover the original demonstrator. The book includes experiments commonly found in such books as Newth's and Benedict's; in other words this is the most complete treatise thus far presented.

The principles of elementary chemistry are usually illustrated by more than one experiment, thus giving the teacher a choice to fit his needs and point of view. The directions and purpose of the experiment are clearly and concisely given, but the descriptive matter is not trivial or too lengthy. The nomenclature is somewhat antiquated, as "spirit of salt," which may bother the young teacher. The source of materials is given only for English firms. This detail seems wholly unnecessary. The experiments are all time proven. There is no doubt of the author's statement that they represent a lifetime of collecting and organization.

Besides this vast number of experiments the author has presented in the introduction and appendices advice to teachers, and constructive suggestions for the improvement of teaching in the most beautiful and inspiring form that I have ever read. The spirit of these pages will cause every reader to attack his lectures with greater zeal. These pages alone are worth the price of the book. No teacher of general chemistry can afford to be without it. It will stand out as one of the great contributions to the better teaching of general chemistry.

HERSCHEL HUNT

PURDUE UNIVERSITY
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ANNUAL REVIEW OF BIOCHEMICAL AND ALLIED RESEARCH IN INDIA, Volume VII. Society of Biological Chemists, Hebbal P. O., Bangalore, India, 1937. 165 pp. 14 × 21.5 cm.

Volume VII of the Annual Review of Biochemical and Allied Research in India contains the following chapters:

"Enzymes," K. Venkata Giri (pp. 1–9); "Proteins of Indian Foodstuffs," Kamala Bhagvat (pp. 10–4); "Vitamins, Hormones, and Plant Stimulants," Bashir Ahmad (pp. 15–28); "Pharmacology," B. B. Dikshit (pp. 29–33); "Human Pathology and Bacteriology," S. M. Banerji (pp. 34–47); "Human Physiology," N. M. Basu (pp. 48–61); "Microbiology and Fermentation," S. V. Desai (pp. 62–6); "Chemistry of Plant Products," C. N. Acharya (pp. 67–80); "Physiology and Nutrition of Plants," B. N. Singh (pp. 81–96); "Agronomy and Agricultural Industries," B. Viswa Nath (pp. 97–106); "Soils, Manures and Fertilisers," A. Sreenivasan (pp. 107–19); "Phytopathology—Mycology," B. B. Mundkur (pp. 120–9); "Phytopathology—Entomology," M. C. Cherian (pp. 130–6); "Dairy Chemistry," C. S. Ram Ayyar (pp. 137–40); "Nutrition of Farm Animals," P. V. Ramiah (pp. 141–5); "Soil Physics," Amar Nath Puri (pp. 146–50); and "Agricultural Meteorology," L. A. Ramdas (pp. 151–5).

The volume also contains author and subject indices.

OTTO REINMUTH

A CATALOGUE OF THE EPSTEAN COLLECTION ON THE HISTORY OF PHOTOGRAPHY AND ITS APPLICATIONS ESPECIALLY TO THE GRAPHIC ARTS. Introductory Note by Hellmut Lehmann-Haupt. Columbia University Press, New York City, 1937. 15.5 × 24.5 cm. $1.50.

This book is a bibliography of photography. The chapter headings are General Works on Photography; Theoretical Foundations; The Aesthetics of Photography; The History of Photography; Technical Evolution; Equipment and Apparatus; The Practice of Photography; The Applications of Photography; Motion Picture Photography; Photomechanical Reproduction; and Color, Color Photography, Color Printing.

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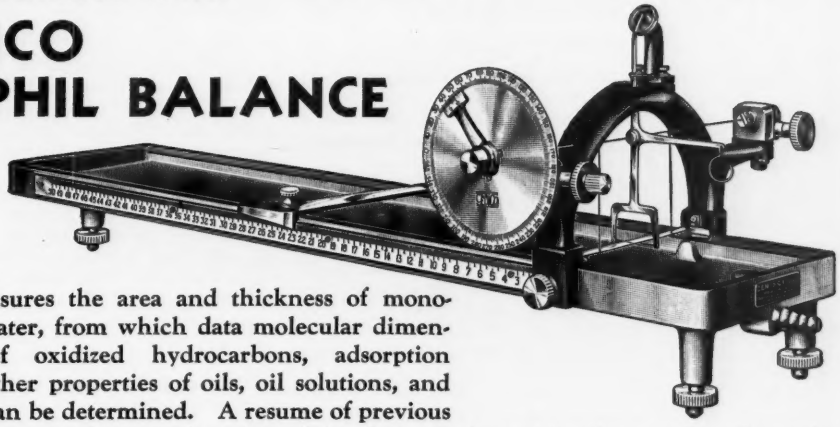

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